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Irrigation and Dry Farming.

Irrigation is a somewhat meaningless term to a good many American people who consider themselves pretty well informed. They have an idea that it is only necessary to build reservoirs or sink wells and nature will furnish water to these artificial works, so that a sage brush plain will become a garden tract. It is this general misconception of elementary facts that gave western Kansas and Nebraska such a bad reputation. The good crops that were raised during an unusual succession of wet years resulted in an influx of settlers who lost all their property when the inevitable dry years came. Towns were deserted as agriculture about them was abandoned and what was once the scene of activity and plenty was abandoned to the coyote and jack rabbit. The same failure to appreciate nature's inability to keep pace with man's demand for water has been causing great trouble in Southern California. There it has at last been learned by costly experience that the underground waters used extensively for irrigation fluctuate with the annual rainfall, and, moreover, are no more inexhaustible than surface streams. In short, there is plenty of experience demonstrating that any land which depends on irrigation must be assured of water in order to be permanently valuable. The engineer can build reservoirs and canals and can lay out large systems of wells, but neither he nor anybody else can control the annual rainfall, which alone makes these works serviceable.

The men who really know what irrigation can and cannot accomplish are the most conservative of all people who are interested in the development of our semi-arid territory. It is a pity that the thousands of settlers who are venturing the savings of their years of toil in this territory fail to appreciate the repeated warnings of these experts. The lean years are certain to come, when the furnace-hot winds will spread ruin over parts of this semi-arid section, and the old story of western Kansas will be retold. As a result the possibilities of this territory will become as underrated as they are now overrated, reports of crop failures and ruined farming districts will be magnified by stock market bears into wild rumors of wide devastation, and, incidentally the irrigation engineer will be blamed for incompetence in not preventing something for which he was in no way responsible.

Anybody who wishes to know just what farming means in most of the semi-arid country will do well to read a brief report on the relation of irrigation to dry farming which was recently written by Prof. Elwood Mead of the Agricultural Department. The prospective settler in this territory should consider Prof. Mead's picture of life there: "Nothing can be more dreary and discouraging than the aspect of the dry farmer's home in midsummer. Without shade trees, without green grass, without fruit, the dead, dusty and lifeless appearance of the landscape is monotonous beyond measure. The fact that many of these farmers are prosperous does not remove the need for trees, fruit, grass and gardens, nor lessen the value of these features of a home as seen on irrigated farms in the same region." The conditions there require the same intelligent persistence that enabled farmers to thrive on the rocky hills or sandy lowlands of New England, and this quality is not always possessed by the settlers, who will doubtless ascribe to ill luck, instead of the lack of proper precautions the ruin that will come with the years of heat and drought.

The bright side of the picture is afforded by the promise of help held forth by irrigation on a small scale. This does not refer to the great public or private undertakings, planned by a large corps of engineers and costing large sums, but rather to modest systems constructed by the settler himself in order to be sure that from one to ten acres on each section will remain productive during the worst seasons. It is this isolated irrigation that is so very important now in order to minimize the troubles which threaten increasingly the dry farms, however scientifically they may be worked. This household irrigation is a demonstrated success, although the amount of water available at one place is generally insufficient to serve more than a small tract. The records of the Department of Agriculture for Garden City, Kan., in the last ten years do not show a single crop failure where a windmill and well furnished water, although there were several years when the failure on adjoining dry farms was complete. Gasoline engines are proving useful for pumping in many places. In some places small reservoirs have been built to store storm water; the Chicago & Northwestern Ry. has over thirty of them in Wyoming and South Dakota as watering places for range cattle. In still other places, the water that occasionally fills runs that are dry most of the time is diverted so as to occupy the pores of the subsoil. This is generally done in winter or spring, and while it is not so satisfactory as the application of the water when the crops most need it, the system is fairly successful.

This view of irrigation is very different from that usually held by people living in the humid regions. It shows that irrigation possibilities in the semi-arid belt are restricted, and that the settler there must generally look to cattle, swine and poultry for his returns and depend upon his small irrigated tracts for his home supplies and for occasional help in saving crops on his dry-farmed lands. These facts are deserving of more general recognition than they have received, not only by the settlers themselves but also by men of affairs who are accustomed to shiver at every report of localized crop failures. What happened years ago to western Kansas will happen again somewhere in the great semi-arid belt before long. It will not be due to poor irrigation or to a "visitation of Providence," but will be the inevitable result of man's attempt to wrest from nature more than she can give.

The Theory of Flexure for Reinforced Concrete.

There has been no lack of theories with the resulting sets of formulas for the flexure of reinforced-concrete beams. Ever since the combination of steel and concrete came into use to a sensible extent as beams, many writers have deduced formulas in great fulness for all elements of the problem, sometimes with a commendable appreciation of the actual conditions found in this class of beams, while others have apparently been moved with a desire to set forth things more novel than useful.

In all this abundant literature of the theory of reinforced-concrete steel beams, there has been an almost if not quite an invariable tendency, or rather a well defined effort, to project into the subject theories or assumptions of certain experimenters or writers, mostly foreign, based largely upon certain refinements of empirical results as expressing supposed novel features of the action of these compound beams. All this serves to give these hypotheses, or assumptions, characters of more or less novelty, although in too many cases it creates obscurity in the formulas reached, the impression apparently being that the latter in this way acquire the advantage of a closer expression of the actual carrying power and other physical properties of the beams or girders under consideration. In other words, the theory of reinforced-concrete beams has been too generally treated as if it possessed a character or qualities different from that of the old, familiar theory of common flexure. As a matter of fact, no theory of flexure of these beams with its resulting formulas has any practical value or in reality has found material recognition in concrete-steel work which is not based simply and solely on the common theory of flexure. Anything that has been injected into the subject conveying a different impression by just so much gratuitously mystifies the general problem, and complicates the use of formulas whose employment ought to be exceedingly simple.

In last week's issue of The Engineering Record may be found a comprehensive and interesting paper by Mr. Richard T. Dana on the subject of flexure in reinforced-concrete beams, in which

he establishes the general formulas required in the design of such beams of the two forms of cross-section most generally used. It is scarcely necessary to observe, as indicated by the author of the paper, that the formulas are not new. There are, however, some features of Mr. Dana's analyses that are worthy of most careful consideration. In the first place his statement of fundamental conditions and assumptions is seen to include, so far as it relates to flexure proper, only those of the common theory of flexure; and it must be observed that it would have simplified the matter if that foundation fact had been made more prominent without reference to foreign investigators in that connection. As highly valuable as their work has been in this general field, that work has no bearing upon the groundwork of the theory proper. The neglect of the tensile resistance of the concrete and the compressive resistance of the steel are wholly secondary matters. They express judicious features of the practical operation of design, but they are not in any way involved in the general hypotheses on which the theory itself is based.

Mr. Dana's assumption of the fundamental law of flexure, that is, that the intensity of stress in any normal cross-section of a beam varies directly as the distance from the neutral axis, is highly commendable. There is in reality no valid reason for making any other assumption, as has been repeatedly shown in other treatments of this feature of the theory. Although the prevailing practice is probably in favor of the use of the straight-line law, the parabolic law has unquestionably had a strong recognition, which it is not easy to explain, except on the ground already alluded to, namely, that there has been a tendency to give to the whole subject a degree of complication not properly belonging to it. A careful examination of the stress-strain curves disclosed in the actual tests of full sized concrete-steel beams shows, as would be anticipated, more or less irregularity, but on the whole the departure from a straight line up to intensities of stress materially above those used in design, are so small that it is scarcely practicable to do otherwise than to neglect them, precisely as is done in the cases of timber beams and those of other materials of such irregular and erratic character as cast-iron and stone. If the straight line is not employed under such circumstances, it would be impossible to determine what line should be used; at any rate it is certain that there is no rational ground whatever for assuming the parabola. Within the limits named the average line is sensibly straight. It conduces to simplicity and it does not violate reasonable accuracy to assume the straight-line law.

The fact that the stress-strain curve departs greatly from a straight line at intensities of stress much above working values is not peculiar to concrete. Indeed, that departure in the case of structural steel is far greater than in the case of concrete, and yet no one would think for a moment of proposing any other than the straight-line law for structural-steel beams. There is, in fact, more reason in this respect for abandoning the straight-line law for steel beams than for those of reinforced-concrete, but in that case the parabolic law would certainly not be adopted as a substitute.

These fundamental elements of flexure formulas should be in as close conformity as practicable with the conditions existing in bent beams as they are actually found in practice. If those are then fitted to the formulas, such empirical quantities representing ultimate intensities of stress as are found by the actual testing of full sized beams, the best formulas for ultimate load now attainable, will result, and a suitable fraction of that empirical quantity is the most rational working stress which can be determined. This general observation is just as applicable to concrete-steel beams as those of structural steel.

In general formulas for this class of beams it is judicious to exhibit the terms representing the tensile and compressive resistances of both the concrete and steel, as is done in some of the best treatments given at the present time. There can then be introduced very simply conditions involving the neglect of concrete in tension, and steel in compression. The resulting formulas will show the bearing and effect of such special conditions, and a more comprehensive view of the whole subject will be conveyed. The most important feature of the whole matter, however, is the establishment of the formulas in such a way as to show the simplicity of their nature and of their application, indicating clearly that they are simply and only extensions of the common theory of flexure to the combined materials.

Rapid Construction of Great Bridge Spans.

Current reports of the progress being made in the construction in the United States and Canada of the greatest bridge spans ever built show rapidity and success far beyond precedent. The three largest structures, namely, the Manhattan and the Blackwells Island bridges across the East River, New York, and the Quebec bridge across the St. Lawrence, represent three out of the four principal types of long-span structures, namely, the cantilever, the simple independent trussed span and the stiffened suspended span, while the 840-ft. arch erected a few years ago across the Niagara gorge furnishes the fourth type of modern long-span bridges, and like the others, excels the dimensions of all former bridge structures of its class. These bridges together constitute practically an epitome of the most advanced features of long-span design, construction and erection. In the conditions prevailing, in the requirements and in the solution of the problem, they represent some of the most important and difficult features of constructional engineering, and show a remarkable advance within a very few years over former methods and appliances.

Up to a very few years ago long bridges, even those with metal super-structures, were necessarily composed of many short spans, and looked at in the light of present operations, their engineering interest often lies chiefly in the sub-structure. A few European bridges were built at a great altitude, as for instance the bridges over the Wupper River in Germany and the Garabit in France, which involved heights up to about 400 ft. over very narrow chasms, and arches of 400 to 600 ft. span. These were all built with light members which could be handled with comparative ease, yet their construction was a matter of several years, appearing very slow in comparison with the usual records for spans of similar tonnage erected in this country. The famous Forth bridge with its two 1,710-ft., double-track spans, and the less well-known Landsdown bridge, with its 840-ft. cantilever span, are the extreme limit for foreign spans, and their erection, although considered successful and satisfactory, occupied many years and involved tedious, dangerous and even inaccurate methods. A large proportion of the work was done piecemeal in the field, such as the riveting and assembling, which are now done far more accurately and cheaply in the shops.

Some of the foundations for the older bridges, as for instance those for the International bridge across the Niagara River at Buffalo, and for the Victoria bridge across the St. Lawrence at Montreal, Canada, are triumphs of successful work under extremely difficult and dangerous conditions. In both of these cases piers had to be built in deep, swift water, periodically carrying enormous fields of ice certain to sweep away any temporary structures. It required several years to build the foundations for the Victoria bridge in open crib cofferdams, drained by crude and imperfect means and calked only by puddle and sheeting. Some of them were used during one season, removed in the fall, and brought back again the next year to complete a single pier. It is doubtful if the courage and ability displayed in the successful execution of this work can be excelled, but since its completion 50 years ago, the methods of handling masonry construction, which in itself has probably changed less than any other form of engineering construction, have advanced so much that work is now done in a totally different way, which immensely increases the rapidity and extends the limitations of the design. Besides, the increasing lengths of the super-structures and the great depths to which the foundations can now be carried will in many cases eliminate the most serious dangers from the fierce current and enable the foundations to be located so as to avoid the worst difficulties.

Two of the three American bridges here mentioned have pneumatic caisson foundations carried to a considerable depth below water level and built in a couple of seasons with an absolute certainty of conditions and results and at greatly less expense than could have been accomplished with the older methods. These bridges also show examples of magnificent masonry constructed in the open air and built with a rapidity that has been attained only by means of the use of special masonry, efficient mechanical plant for handling, transporting and hoisting materials, and the abundant use of ample steam, pneumatic and electric power in the execution of the work. A large part of the volume of the masonry is of concrete, which with the complete installations for storing, mixing and handling can be put in place much more uniformly and rapidly than solid stone. The use of a large proportion of large stones imbedded in the concrete also expedites its construction, and the reinforcement of other portions with steel rods increases its strength and extends its application so that with the outer faces of ashlar granite enormous monumental piers are built very rapidly, as recently noted in the descriptions of the anchorages for the Manhattan suspension bridge.

Millions of dollars have been expended by a few of the principal bridge builders in this country for the construction of plants especially adapted to the manufacture of heavy railroad bridges, and their equipment of special tools of great power enables them to complete individual truss members of a magnitude hitherto entirely unapproached, many of them fully as large and heavy as complete short-span railroad bridges. These members are finished with such accuracy that although they are seldom matched together in the shops, the rigid inspection practiced insures their fitting within the required clearance of a very small fraction of an inch when assembled for the first time in the field high above the water, swinging in tackles where readjustment or alteration is impossible and where any failure to connect would mean a critical hazard.

The dimensions of these pieces have already reached the practical limits imposed by the facilities for manufacture and transportation, and some of them require special steel cars of unusual strength, or must be loaded on several cars tandem to accommodate their great length—a factor that evidently determines the present limit of size for such purposes. At the bridge site these pieces are handled by rapid working derricks of great capacity and by traveling cranes of the gantry type, with which they are assorted and piled high in regular sequence ready for delivery exactly as required for the successive stages of the erection.

The great super-structures for the anchor or independent spans 600 ft. or more in length, and much stronger and heavier than any spans have

previously been built, are being erected on falseworks which in themselves are important steel structures equivalent to first-class railroad viaducts. Provision is made to compensate for the settlement likely to occur under their heavy loading as well as to provide for the lifting of the thousands of tons of the assembled superstructure which they will carry in order to provide for preliminary adjustments and the final connections in the erection. This involves special girders, platforms and very powerful hydraulic jacks. On these temporary platforms the great trusses are erected by means of steel travelers equipped with derricks and with suspended fixed tackles of capacities reaching considerably above 100,000 lb. each and operated by steam or electric hoisting engines developed for this special service from the results of many years' experience in erection work.

In order to handle the heavy members of the trusses many forms of special attachments have been designed to insure safety, simplicity and quick operation, so that a 100-ton piece can be suspended from its tackles in such a way that it can hang freely, swing into the required position and be promptly released with a minimum of time and labor. Once in position, the members are cured either permanently by steel pins in the principal connections or temporarily by smaller wooden pins or by service bolts in the rivet holes, thus enabling the construction to proceed without waiting for the final adjustment and completion of all the connections. The pin connections, so characteristic of American designs, obviate a very important delay in assembling which would be greatly prolonged if, instead of one pin locking together all the members meeting at a panel point, it were necessary to fit and insert a great number of rivets or bolts, as would otherwise be required and is actually done with other types of construction.

In the erection of long truss spans the cantilever method solves many problems which would otherwise be impossible, except for suspension bridges. For such great spans now under construction special steel travelers of a Z-shape type have been developed which are proving very efficient in assembling the members in advance of the completed structure. They are able to handle members in both trusses simultaneously, supporting them until connected to the finished portions of the truss so as to become self-supporting. With their scores of large tackles, hoisting engines, self-propelling apparatus, suspended platforms and auxiliary appliances for driving 16-in. chord pins 10 ft. long by hydro-pneumatic pressure, they constitute remarkable tools indispensable for safe and rapid progress with work of such magnitude. With them and the other appliances noted work is erected at the rate of hundreds of thousands of pounds daily, and with them the great spans may be completed in comparatively few months working time as compared with the years previously expended on structures of inferior magnitude.

In the recent erection of the suspended superstructure of the 1,600-ft. Williamsburg bridge, the longest span of its class existing, considerable advance was made over previous suspension bridge work in the rapidity of weaving the main cables and in the building from them of the trusses and floor systems. This was accomplished both by new methods and new apparatus, and it is expected that in the construction soon to be commenced of the similar Manhattan bridge these improvements will be greatly increased.

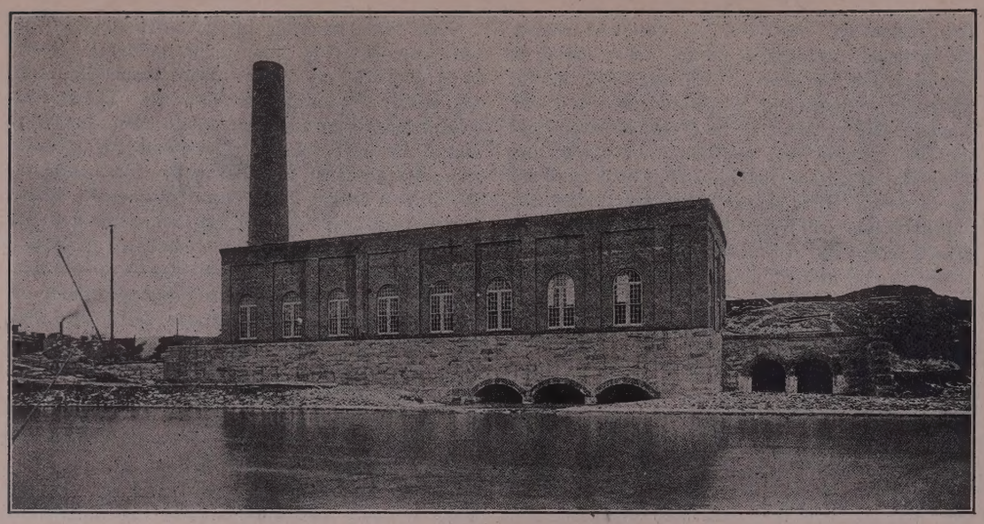
The development of long-span bridges in this country and their commercial success fully justifies the characteristic features of design, construction and erection here considered. All branches of the work are in the hands of highly trained specialists who have so far shown marked improvements in almost every successive span of great magnitude. As the final criterion is usually the financial justification of the construction, it is evident that the practice of bridge building, and especially its important factors of rapid and safe erection, will continue to be perfected largely on the lines of the best application of power and of special apparatus for supporting and handling the members. It is probable, however, that these improvements will result more conspicuously in greater economy of work than in a notable increase in the present dimensions of great structures.

Notes and Comments.

DEEP TRENCH EXCAVATION in wet sand has proved more economical than tunneling on sewer work at Sydney, N. S. W. The test was made where the sewer was 22 ft. below the surface. On the first section the excavated material was thrown from stage to stage, being handled four times. To save this handling an overhead cable was supported by masts over the line of the trench and the sand was lifted by a hoisting engine and traveling block. This device reduced the cost of excavation from $1.86 per cubic yard, the figure when casting was employed, to $1.62; the sand carried more water where the cable was used, which made the reduction in cost an incomplete measure of the actual gain. The cable was 350 ft. long and the masts were 34 ft. high. This method of excavation was more economical than tunneling, and the expense of laying concrete and brick in the trench was nearly 50 per cent less than in tunnel.

FORMER AND PRESENT-DAY INDUSTRIAL DEVELOPMENT DIFFERENCES are well illustrated by the history, given in an article printed elsewhere in this issue of the Holyoke, Mass., hydraulic power plant. Begun before the middle of the last century, the initial plans were very similar to those of the first Niagara electrical development, formulated more than forty years later. In the latter case there was no halt from the inception of the work to its completion, notwithstanding the originality of most of the engineering features, the vast outlay of money and no little indefiniteness as to the financial outcome. At Holyoke the early plans, which, according to present-day ideas, were excellently founded and entirely feasible of execution, had to be abandoned, and the development allowed to proceed, apparently, as opportunity of the moment permitted. If the commencement of the development had been a generation later, the utilization of the 30,000 h.-p. available would have created at Holyoke a center of electrical activity only second to Niagara Falls. Actually the present plant is built only for an ultimate generating capacity of 3,000 h.-p. The plant presents nothing particularly new in construction and general equipment, but is interesting from the careful manner in which all the engineering details have been developed. Reduction of water flow in summer and during abnormally dry seasons demanded an auxiliary steam equipment, which in this case is of the most economical character from the operating standpoint. Formerly in working out the details of a steam plant for auxiliary or emergency purposes, a consideration of the fixed charges usually indicated that a minimum total annual charge corresponded to a cheap steam installation with, naturally, low operative efficiency. The advent of the steam turbine generator has changed this condition, and a highly efficient auxiliary steam plant may now be installed at little greater cost than an uneconomical plant of the old type. As pointed out in the article, the turbo-generator has also a great advantage in case of emergency call, owing to the rapidity with which it can be brought into service.

THE TWO HEADINGS in the north tube of the twin tunnels being built under the North River at New York City by the Pennsylvania Railroad Co. met on Wednesday of this week. The shields in the south tube are expected to meet about the end of the first week in October, and it is believed that the tunnels will be ready for operation within two years. The general plans for a Manhattan Island terminal for the Pennsylvania R. R. and various features of the methods of construction that have been followed in executing these plans have been described in previous issues of this journal. The North River division of the terminal project is 13,700 ft. long, and extends from the terminal, now under construction on Manhattan Island, by two main line tracks under the river and through the hill on the New Jersey side of the river. The portion of the tunnel actually under water is 6,100 ft. long, although the tunnel section of the North River division is 7,000 ft. long, extending beyond the water line on both sides. The under-river portion of the two tubes have the same general cross-section and are built according to the same general design as the four tubes under the East River, which were recently fully described in this journal. The two tubes have been driven from a shaft on each side of the river, work on the tunnels proper after the completion of the shafts having been begun on the New York side April 18, 1904, and on the New Jersey side Sept. 1, 1904. The rate of progress that has thus been obtained in this work is truly remarkable when the character of the material encountered, the construction limitations presented on both sides of the river, and the heavy air pressure under which all operations in the shields have been carried on are considered. The bottom of the river is largely a soft silt, although the tunnels were driven in rock for some distance at both land ends. When the work in the rock had progressed as far as it was thought safe the shields which have been used in driving the tunnels were built. Many different kinds of materials have been encountered since operations in these shields were started, including full-face rock, rock with gravel overlying, composite face of rock and sand, full-face of gravel and boulders with occasional thin seams of clay, full-face quicksand, composite face of sand underlying silt, and full-face silt. Piles, riprap and docks back of the bulkhead line on both sides of the river also greatly interfered with the work. The shields that have been used in driving the two tubes are built according to the designs of Mr. Charles M. Jacobs, chief engineer of the North River division of the Pennsylvania R. R. terminal improvements. It was hoped that they could be pushed forward in full silt by displacing the material through which they passed, without removing any material through them. Except under unusual circumstances, however, it was found necessary to take out not less than 25 per cent. and sometimes as much as 100 per cent. of the displacement, the principal factor of this requirement being the alignment. The same difficulties that have been experienced in the construction of the East River tubes in balancing the air and water pressures at different heights at the working face in the shields were met in these tunnels, especially on the New Jersey side, where quicksand was encountered. The contractor for the work, the O'Rourke Engineering Construction Co., deserves much credit for the rapid progress that has been made, and it should be noted further that in the two years and more required to drive the tunnels under the river only one life was lost, and only one death was attributable to the effect of compressed air. When the technical features of this work are made public there will doubtless be more of great interest added to the knowledge of subaqueous tunnel construction than has ever been contributed by the experience obtained from any single project.



The New Power House of the Holyoke Water Power Co.

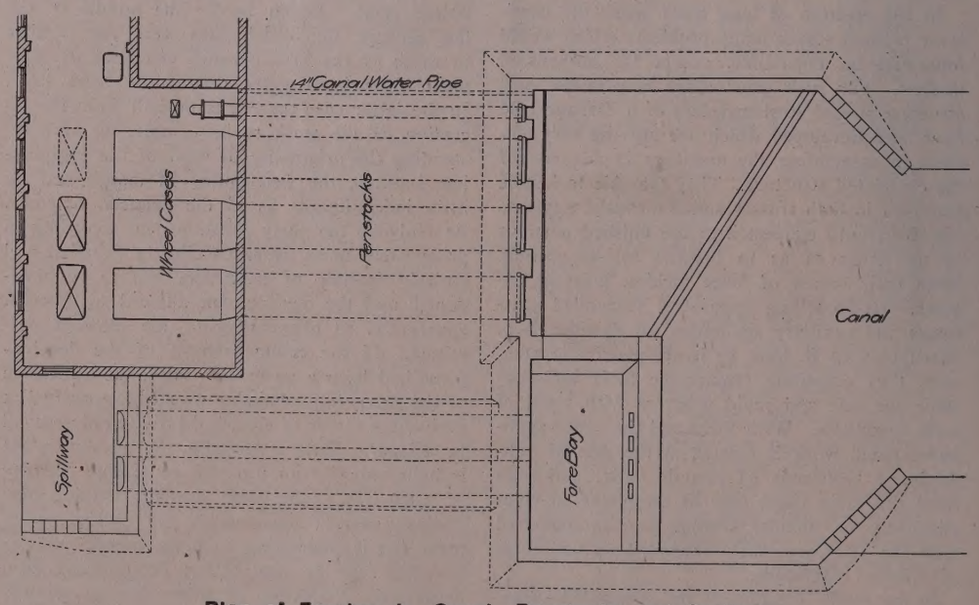
THE NEW HYDRO-ELECTRIC STATION OF THE HOLYOKE WATER POWER CO.—I.

The water power of the Connecticut River at Holyoke, Mass., is the largest in New England and the development at this point is one of the largest in the United States. The development here dates from the summer of 1847 when a wooden dam was built across the river by the Hadley Falls Co., a company organized to maintain a dam, power canals and create power developments for manufacturing purposes. The company purchased 1,100 acres of land, established canals and mills, and laid out a city, preparatory to the creation of an important manufacturing center which should, according to the original intention, attract cotton mill industries to this point. The first dam built failed before the water reached its crest, but owing to the fact that gaugings at low water periods indicated that over 30,000 hp was available, a second dam was at once begun and finished in 1849, which, at the time of its completion, was the largest in the world. The company, however, encountered financial difficulties during the hard times of 1857, which resulted in a subsequent reorganization and prosecution of the work on a new plan. Instead of attracting cotton mills, a number of paper mills were installed which were followed by others until Holyoke is now one of the greatest paper producing centers in the world.

In 1891 surveys were begun for a more substantial stone dam, which was built in front of the wooden dam, the latter not being removed. About 10 years was taken in the building of this dam, which has a total length of rollway between abutments of 1,020 ft. The dam has a height of 30 ft., is 54 ft. wide at the base and 7 ft. at the crest. The downstream face of the dam is shaped with special curves, which were assumed to pass the water over with the least possible disturbance; the accompanying illustration of the dam shows it during high water conditions. A series of flashboards have been mounted on the crest of the dam to increase the head during low water. The face of the dam is of granite cut for ¼-in. joints and polished on the top. The up-curve at the extreme toe is designed to break the force of the water and prevent its cutting into the ledge beyond. The slope of the up-stream face is equivalent to a batter of one foot in five. It is stepped off every five feet in height in order to afford a footing for the cofferdams. The dam is considered to be an exceptionally fine piece of masonry and is faced with ashlar.

The power facilities that were eventually developed by the Holyoke Power Co., successors to the original company, embrace three distinct power canals which were built in the city at different levels, and between which the mills are similarly located on three different levels, so as to utilize the fall of the water serially in three stages. The upper level canal takes water from above the dam through 13 gates, each 15 ft. long by 8 ft. wide, and extends eastward from there, with a width of 140 ft., and a depth of 22 ft., about 1,000 ft., and thence southward in a straight line for more than a mile, to supply the upper tier of mills, the width gradually lessening at the rate of one foot in every hundred. The second level canal begins opposite the terminus of the reach of the upper level and runs in a northerly direction for a mile or more, parallel to the upper level canal and 400 ft. east of it, serving as a tail race for the upper level and also as a canal for the supply of the mills below. The second level canal then flows east and south for a mile and a quarter more at a distance of about 400 ft. from the river, this marginal portion of the second level affording mill sites along its entire length, from which the water is discharged directly into the river. For 2,000 ft. this canal has a width of 140 ft. and thence the sides gradually converge to a width of 100 ft., which is continued to either end, the average depth of water being 15 ft. The third level canal, 110 ft. wide and 10 ft. deep, is also a marginal canal with mill sites along its entire length. It begins at the southerly end of the second level, extends 3,550 ft. to the other terminus of the same canal, thus making with the latter, a line of marginal canals around and near the whole water front of the city. The mills on the upper level have a head and fall of 20 ft., the difference between the second and third levels is 12 ft., while the fall between the marginal canals and the river varies from 23 to 28 ft. The total head from the crest to the tail water from the third level canal at the average height of the river is 60 ft. Thus most of the water is used three times. The amount of power available at the present time is estimated to be 30,000 h.-p., which is based on measurements taken of the daily average flow of the river, amounting to 11,951 cu. ft. per second. The drainage area of the Connecticut River above the dam is estimated at 8,000 sq. miles.

With the rapid growth of the city as a paper manufacturing center and increased use of the water power, it recently became evident that few available sites for new mills along the power canals were left, so that the only opportunity for future development of manufacturing industries would be in the unoccupied districts farther back in the city which would necessitate the use of some means of power transmission in order to utilize the excess of water power still available. Furthermore the necessity had arisen for the installation of another spillway or overflow from the second level canal to the river in addition to the three already provided, as a precautionary measure, since if the mills on the second level canal were to shut down for any reason while the mills on the first level canal should continue in operation, the water in the second level canal would overflow its banks because of the inadequacy of the existing overflows. For these reasons and, in addition, the fact that surplus capacity valued at about $100,000 per year was being continually wasted, the company decided to erect a power station at the most convenient point hydraulically, where the surplus capacity of the river could be used to furnish power to available sites on the opposite side of the canal and on the river front, where the expense of building water connections from the canals to the mills would be prohibitive. With this idea in mind the company applied to the legislature for a charter empowering it to produce electricity for power purposes, which was granted in May, 1903. This charter provided that the company should sell power to any purchaser in any quantity not less than 100 h.-p. at any time, and that the purchaser should not use the electricity elsewhere than in his own business only and on his own prop-



Plan of Forebay in Canal, Penstocks and Spillway.

erty. After permission had been obtained from the harbor and land commissioners to erect the plant on the river bank, together with permission from the board of aldermen to erect poles and string wires in the city, ground was broken for the new station only a little over a year ago. According to the act passed by the Legislature, the new plant had to be ready for business three years after the passage of the act, which requirements were met.

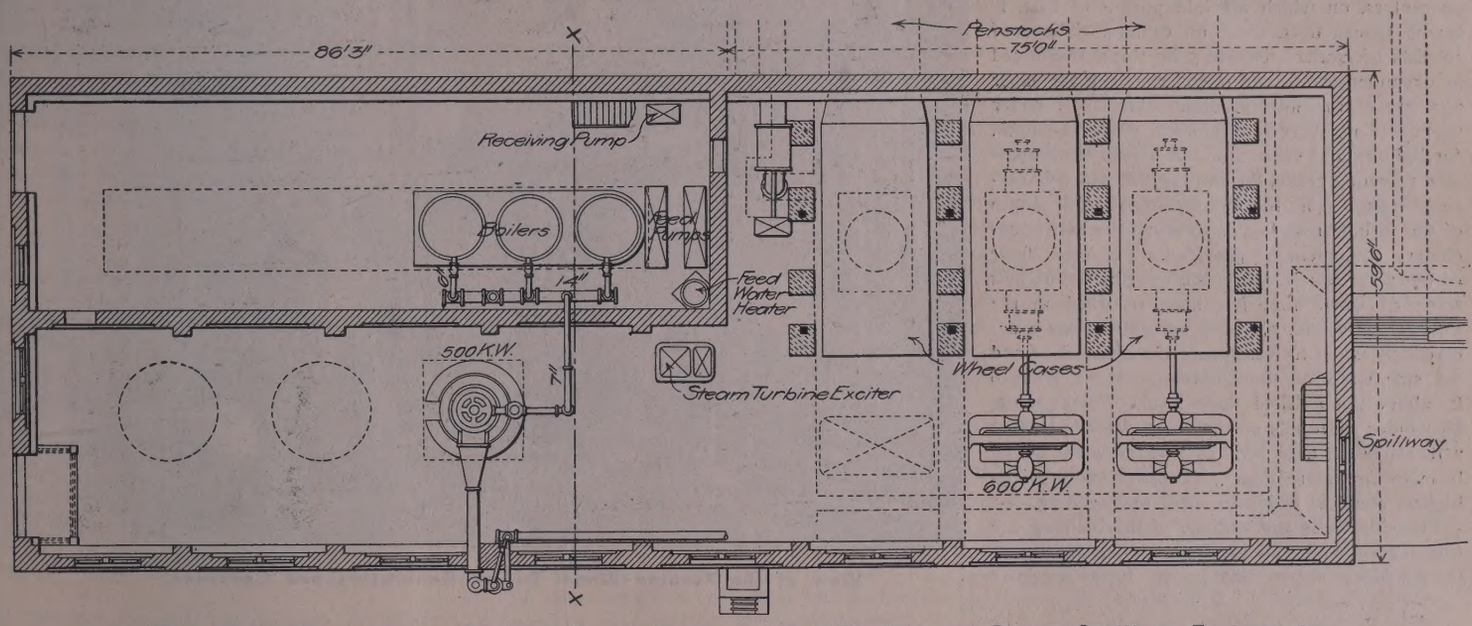
The station is erected on a section of land, 2,000 ft. in length, representing the most valuable unoccupied mill sites in the company's possession. There is a large portion of this tract still remaining, however, which is available for mill sites, the power for which can now be furnished from the new electrical plant instead of by water wheel. To use water at any of these sites would necessitate large expenditures for penstocks alone, since these would have to be carried under two railroads and a street to connect with the intake canal.

Midway between Mosher and Appleton Sts. in Holyoke, is an extension of the second level canal which it was decided to utilize as a feeder to the electrical plant. The inlet from the second level canal to the extension is provided by five arches and one ice way, and the head and fall at normal river level at this point being 32 ft. These arches and ice way carry three tracks of the Boston & Maine R. R. and also a street. The canal extension is 120 ft. wide at the line of full canal and 80 ft. at the bottom with a depth of water of 10 ft. The canal terminates just west of three freight tracks of the New York, New Haven & Hartford R. R., at which point the forebay was located with head gates and a spillway. Four penstocks running from the head gates at the terminus of the canal supply the water to the power plant, three of which penstocks are 11 ft. in diameter and supply the three turbine wheels driving the alternators, while the fourth penstock is 3 ft. in diameter and supplies the wheel driving an exciter unit. The penstocks are 75 ft. long and pass under the New York, New Haven & Hartford R. R. tracks, connecting directly with the water-wheel cases, which are 13 ft. in diameter and 34 ft. long. In each wheel case are two 39-in. McCormick wheels discharging through draft tubes into raceways and thence to the river.

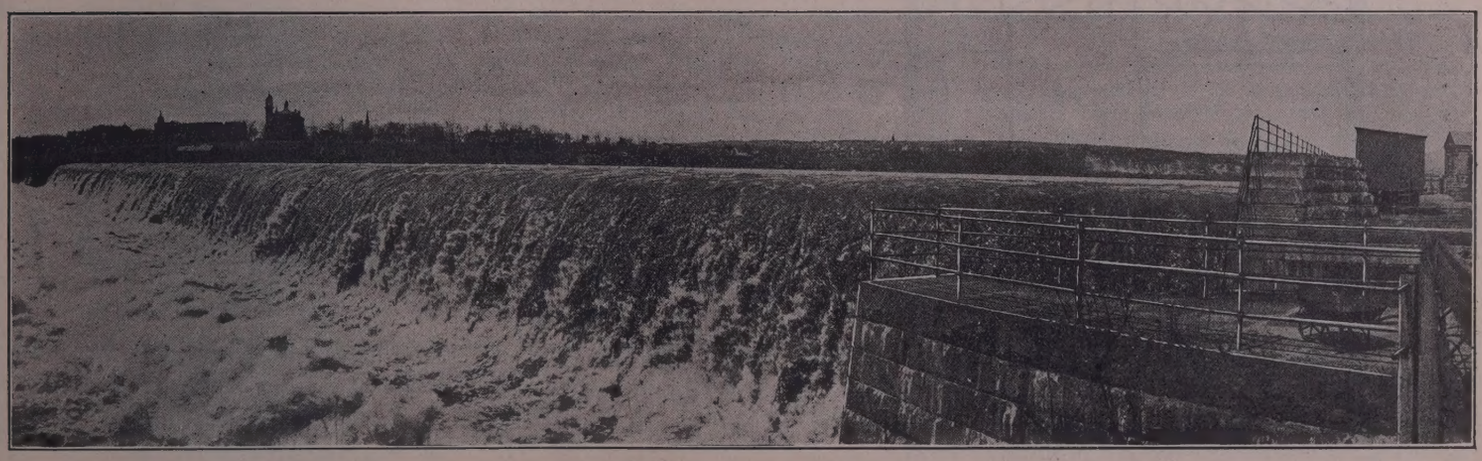
At the terminus of the canal, in addition to the head gates, an overflow to control the height of the water in the second level canal is provided. This overflow is of granite masonry with a spillway 75 ft. long and is fitted with four 4½x4½-ft. wicket gates and removable flash boards 3 ft. in depth. The capacity of the spillway is 60 mill powers, a mill power at Holyoke being considered equivalent to 65 h.-p. The arches at the intake rest on grillages of 12x12-in. hemlock on gravel, covered by 6-in. hemlock, splined. The side walls are of concrete and the arches are of brick. Where the railroad tracks cross the penstocks concrete piers 2 ft. thick are provided to relieve the penstocks of pressure from passing trains. A 16-in. cast-iron main is also laid from the canal to the power house for water for boiler-feed purposes and also for condensing purposes. Each penstock is provided at the head gate with an 8-in. cast-iron vent pipe to admit air and prevent the vacuum which might form in it owing to sudden closing of the gates. No trouble is anticipated with ice in winter since this can be shunted out through the spillway into the river.

For the present requirements the capacity of equipment necessary was not over 1,000 h.-p. and accordingly two 1,000 h.-p. turbine wheels have been installed, one for reserve purposes, while space for a third is provided to permit future extensions. Owing to the reduction of flow in the river in the summer, and moreover, the possibilities of restricted flow in an abnormally dry season, it was deemed advisable to provide a steam auxiliary equipment. It was foreseen that such an auxiliary equipment would be essential as an insurance against interruption of power supply through any possible emergency, and in addition, would be of assistance in carrying temporarily increased loads. As to the capacity required in this auxiliary equipment, it was thought that 600 to 700 h.-p. would be sufficient for present needs, and accordingly 600 h.-p. in boilers and a 500-kw. steam turbine generating unit, with reserve space for tripling this capacity, was installed. From gaugings of the river for the past 20 years experience has shown that in wet years the steam plant will be required only 2 per cent. of the time, while in dry years, when the rainfall is much below normal, the steam plant will be used about 30 per cent. of the time.

The power house is located at the foot of East Dwight St., on the west bank of the river, and



Plan of the Power House Showing Arrangement of Hydro-Electric and Steam Auxiliary Equipments.



View of the Dam at Holyoke during High Water Period.

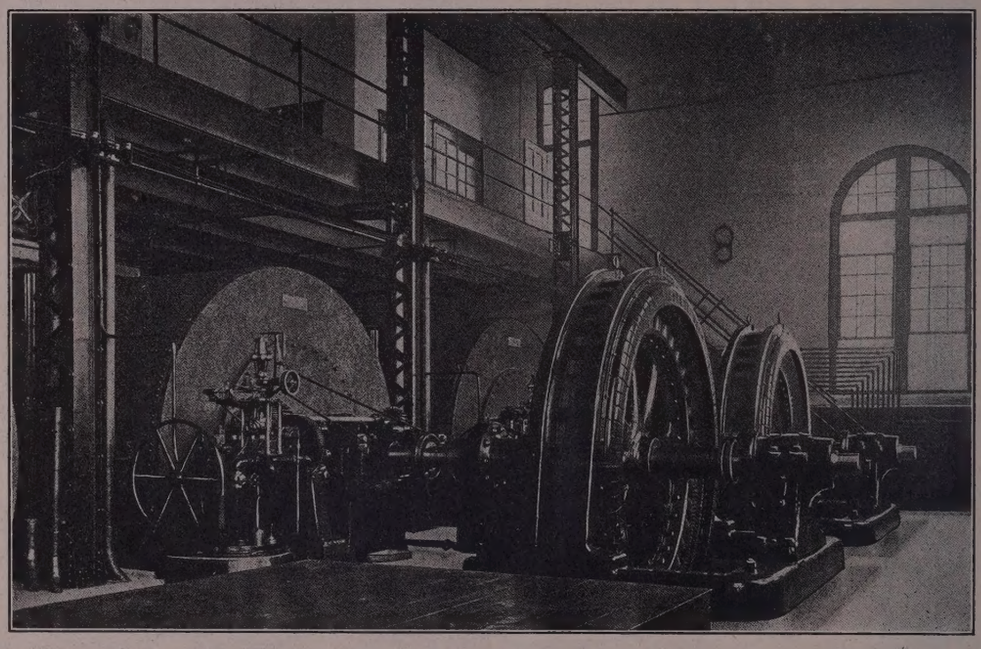
consists of a brick and steel structure, 161 ft. long by 60 ft. wide. The north 75-ft. of the building is devoted to the hydro-electric equipment; the steam auxiliary equipment of the plant, which was installed to insure continuity of the power supply, occupies the southerly portion of the power house, 86 ft. in length. The latter division embraces a turbine room 28 ft. in width which is a continuation of the wheel room, and a boiler room 27x86 ft. in plan, which is separated from the remainder of the building by 24-in. brick division walls. In all portions of the building there is a clear head-room under roof trusses of 34 ft. The construction of the building is very substantial, involving concrete foundations and footings and 24-in. brick side walls. The roof is carried by steel roof trusses, located 9 ft. apart on centers, on which are laid purlins of 6-in. I-beams spaced 6 ft. apart on centers. The roof consists of cinder concrete 5 in. thick, reinforced by expanded metal, and is covered with tar paper and gravel for waterproofing. Over the boiler room section, there is a monitor, 66 ft. in length, for lighting and ventilation. A 10-ton hand-operated traveling crane, the runway for which is carried through from the wheel room the full length of the turbine room so as to serve the entire machinery equipment, is provided. The main floor of the plant is 4 ft. below the level of the highest stage of water that has been recorded in the Connecticut River. Special precautions were accordingly taken to waterproof the entire floor and the side walls of the building up to a point 6 ft. above the finished floor level. Furthermore, all window openings on the river side are located 7 ft. above the floor level so that the water would have to rise more than 3 ft. above its previous highest stage in order to enter the building.

The side walls and ceilings of the building are tinted dead white, all the iron work is black and the machinery a deep olive green. Large windows furnish an abundance of natural light by day and at night the interior is illuminated by clusters of incandescent lamps. The floors are of a cement compound of a deep red color bordered with black, which is resilient and noiseless. The compound is in all cases extended up in a curve at the edges of the rooms to form a baseboard, thus avoiding angles or cracks at the junctions of the floor and the baseboard which serve as dust and dirt traps. Every convenience for the comfort of the employees has been installed such as lockers, toilet rooms, wash rooms, shower baths, etc.

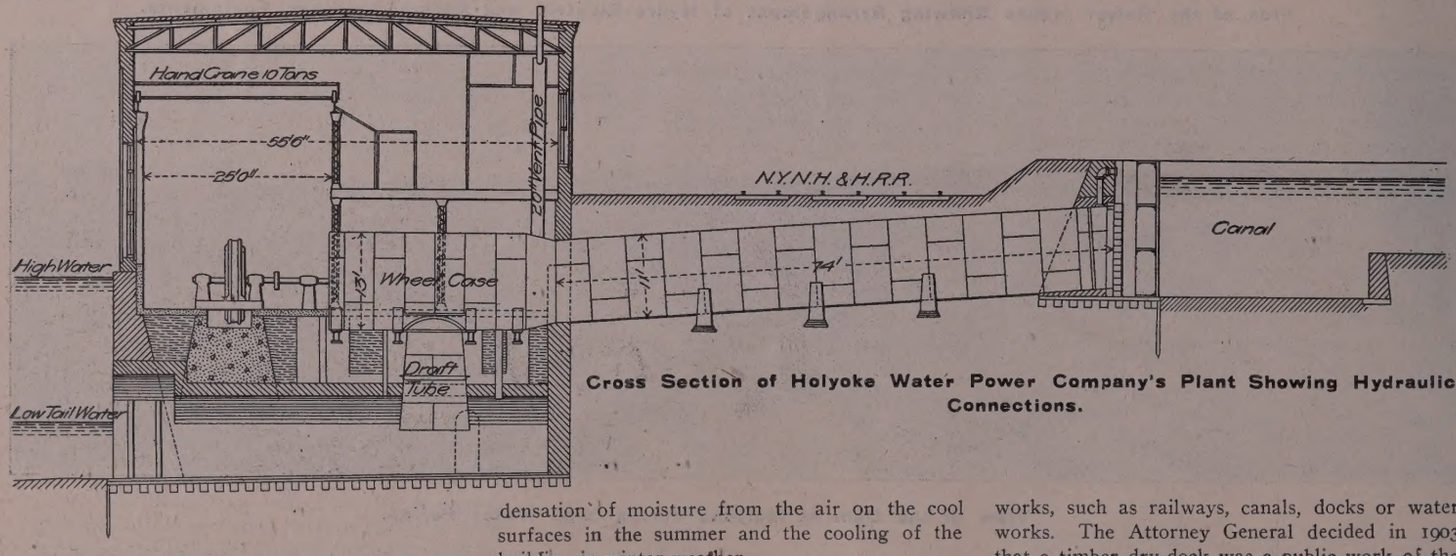
Accompanying engravings illustrate the interior of the station and the arrangement of the apparatus. The turbine wheels are located under the switchboard gallery and have direct shaft connections to the generators, which are 600-kw., 2,300-volt, three-phase alternators. They are each governed by one of the new type N Lombard governors driven from the generator shaft and, for ease of adjustment of the speed of the turbines for synchronizing the alternators, these governors are fitted with motor-operated speed changing mechanisms; the motors are operated from the switchboard so that the attendant in charge may by pressing either one of two push buttons raise or lower the speed of either wheel at will. An interesting feature of the wheel installation is that the wheel cases are all covered with a cork insulating compound which both prevents condensation of moisture from the air on the cool surfaces in the summer and the cooling of the building in winter weather.

The new generating plant was designed by and installed under the direction of the engineering department of the Holyoke Water Power Co., of which Mr. James M. Sickman, who has been for many years closely identified with the engineering department, was engineer in charge of construction. An interesting feature of the plant is that the greater part of the apparatus used in its equipment was built at Holyoke. The stone dam which was completed in 1899, was designed by Mr. Clemens Herschel while he was hydraulic engineer of the company from 1879 to 1889. In the following issue reference will be made in detail to the steam auxiliary equipment which has been installed to ensure continuity of service.

(To be Continued.)



View of the Turbine-Wheel Driven Generators and Governor.



Cross Section of Holyoke Water Power Company's Plant Showing Hydraulic Connections.

The United States Eight-Hour Law; Its Constitutionality and Construction.—II.

By William B. King, Member of the Bar of the Court of Claims.

Construction.—The questions now requiring consideration are questions of the meaning and scope of the statute. Upon this there have been numerous interesting decisions.

Public Works.—The law forbids more than eight hours' work "upon any of the public works of the United States." What is a public work? The ordinary definition would include fixed works, such as railways, canals, docks or water works. The Attorney General decided in 1903 that a timber dry-dock was a public work of the United States (20 Op. 445).

The master of a Government snag-boat was prosecuted for requiring laborers engaged in removing obstructions to navigation to work more than eight hours a day. The court held that these men were engaged upon public works of the United States. (United States v. Jefferson, 60 Fed. Rep. 736), saying (p. 737):

"Men employed in removing obstructions are employed upon public works, and they are to be deemed to be engaged in public work while they are actually working upon the obstructions, and during the necessary time employed in going to and from the places where the work is to be performed and the places where they have to lodge or where they go to meals; and they are also to be deemed engaged in labor upon such public

work when they are necessarily required to repair their tools, or grind axes, or do work of that kind."

Different courts have defined under other laws the term "public works," and have held sewers, public buildings, roads and water-works to be public works.

Decisions may also be cited showing what are not public works. A contractor was prosecuted in a United States Court in Alabama for working his men more than eight hours in building barges for the United States, in his private yard under contract. The judge said that these were not public works, since they remained the property of the contractor until delivered. He then defined public works (United States v. Ollinger, 55 Fed. Rep. 960):

"It is clear to me that the building of the barges was in no sense a part of the public works; no more so than the mining of coal contracted to be furnished to the navy and marine service of the United States according to specifications as to quantity and quality, or the furnishing under contract with the Government of the United States of lumber and brick to be used in building quarters at Mt. Vernon barracks for officers or soldiers or any other public use, according to specifications as to kind, quality, and quantity. It would hardly be contended that the mining of such coal, the sawing of the lumber, or making the bricks would be public works in contemplation of the act of Congress, or that the laborers engaged in the work of mining and in making the lumber and bricks were the laborers whose services and employment Congress has undertaken to regulate and limit. I fail to see any difference in principle in the cases mentioned and that under consideration."

A similar decision has just been made by the Appellate Division of the Supreme Court of New York.

The Attorney General, shortly after the passage of the eight-hour law of 1892, held that a contractor furnishing Post Office lock boxes to the Government was not engaged upon public works of the United States (20 Op. 454). Very recently he has decided that work upon a war vessel was not within this statute and applied the same rule to a contract for furnishing supplies for the Quartermaster's Department of the army.

These decisions are believed to be substantially correct, and the principle underlying them can be readily applied to any given case. This principle seems to be that the public works of the United States referred to in the statute are such works as river and harbor improvements, structures in navy yards, irrigation works, public buildings or other fixed structures under the control of the United States.

Such works need not be upon property ceded by the State to the exclusive jurisdiction of the United States. United States vs. San Francisco Bridge Co., 88 Fed. Rep. 891.

Who May Be Prosecuted.—The statute says that any officer or agent of the United States or any contractor or sub-contractor employing laborers upon public works in the United States may be punished for violation of this law. In the case already quoted arising in Alabama the judge used the following language (United States v. Ollinger, 55 Fed. Rep. 959):

"To render the defendant amenable to this law he must have been an officer or agent of the Government of the United States, or a contractor or sub-contractor whose duty it was to employ, direct or control laborers or mechanics employed upon some of the public works of the United States."

In another case in California the indictment was against a corporation, the San Francisco Bridge Co. (88 Fed. Rep. 891), and the corporation was found guilty. (See also United States v. John Kelso Co., 86 Fed. Rep. 304.)

The law says that a contractor or sub-contractor may be punished. Where the contract is with a corporation this language apparently does not permit the indictment of any officer of the corporation. The corporation itself, it would seem, is the only offender against the law who can be charged in a criminal court. This point was not raised in recent prosecutions under this statute against some corporations engaged in Government work in the District of Columbia. The officers of the corporations were arraigned. The District Attorney assented to purely nominal fines, and they probably thought it better to submit to these than to incur the risk of a substantial fine against the corporations.

What Constitutes Work.—The law says that a laborer or mechanic shall not be required or permitted to work more than eight hours in a calendar day. In the case already cited in which workmen were employed in removing obstructions to navigation, the court defined what constitutes work within the meaning of this law, saying (United States v. Jefferson, 60 Fed. Rep. 737):

"Anything that is incident to their labor in the public work is to be deemed labor upon that public work."

The converse of this occurred in a case before the Court of Claims under the statute which gives extra pay to letter carriers for time "employed in excess of eight hours a day." The carriers claimed that they were entitled to extra pay for brief idle periods between active periods of duty, when no work was assigned to them and they were permitted to go where they pleased. They claimed that very short periods were of no practical value to them and should be counted as continuous work. The Court of Claims held that they were employed only when held to duty, and not when relieved from all responsibility.

Who Are Laborers and Mechanics.—Another most important question arises in relation to the classes of persons for whose benefit the act was passed. They are defined as "laborers and mechanics." It is unlawful to employ any such person more than eight hours a day, but any other person may be employed indefinitely.

The word "laborer" occurs in many statutes and has been repeatedly defined by many courts and with some contradicitions. Most of the definitions have been made under statutes giving some superior lien to laborers for their pay, and the broad definition which some courts have given has been influenced by the desire to give to all persons rendering actual service the protection of remedial statutes.

The distinction has generally been drawn that the word "laborer" means "one who performs manual labor." Among those who have been held to be laborers are firemen, house-painters, plasterers, printers, boys of all work, mail carriers, livery-stable keepers and bar-tenders, while it has been held at different times that the following were not laborers: Architects, draftsmen, auditors, traveling salesmen, editors, consulting civil engineers, locomotive engineers, superintendents, time-keepers, general managers, inspectors, salaried officers, lawyers and physicians and hotel cooks.

The chief controversy has occurred over such men as foremen, overseers, or superintendents. Some of the courts have held them laborers and some not laborers. The line of discrimination seems to have been chiefly as to whether they were engaged simply in superintendence, or partly in manual work.

Bookkeepers, clerks and store salesmen have also been the subject of contradictory decisions, a minority of the courts holding them to be laborers. Even a private secretary was held by one court to be a laborer, as was also a telegraph operator. School teachers have in some cases been given the benefit of laborers' laws and in others deprived of them. Sub-contractors have generally been held not within the protection of laws passed for the benefit of laborers, but miners who work by the piece, employing their own laborers or helpers, have themselves been classed as laborers.

What line of discrimination would declare a bar-tender a laborer and a hotel cook not a laborer is difficult to determine. In a general way we believe that contractors do not violate the law in employing without limit their clerical and superintending force, except that a foreman who performs manual labor as a part of his work is probably to be considered a laborer.

The definition of the word "mechanic" involves the same difficulty in application to actual cases. It has been said by some courts that all mechanics are included within the term "laborers." Courts generally define the mechanic as "a skilled worker with tools." The general discrimination between the meaning of the words "laborer" and "mechanic" appears to be that the latter involves the idea of skill in the use of tools.

Among mechanics courts have included bakers, barbers, carpenters, civil engineers, merchant tailors, plasterers and printers. In including civil engineers an exception is at once apparent to the rule above stated by some courts, that all mechanics are laborers, since all agree that civil engineers are not laborers.

Among those who are held not to be mechanics are abstracters of title, architects, draftsmen, builders, conductors, farmers, manufacturers, millers, photographers, superintendents, salaried employees and material-men. The courts have disagreed as to whether sawmill owners are or are not mechanics, and a similar disagreement has occurred in regard to painters and dentists, although it would be supposed that there would be no difficulty in holding that a painter is a mechanic and a dentist is not.

Employment Not by the Day.—There have been some decisions of courts under statutes fixing a limited number of hours as a day's work under private contracts holding that such statutes have no application whatever to laborers employed otherwise than by the day.

An example of such construction was found in a decision in Indiana, Helphenstine v. Hartig, 5 Ind. App. 172. The plaintiff was employed as an engineer at a weekly wage. He worked twelve hours a day without further agreement. The statute fixed eight hours as a day's labor. The court said:

"The employment in this case was by the week, and we do not believe the legislature intended the act mentioned to apply to laborers employed, except by the day."

The Supreme Court of Michigan in Schurr v. Savigny, 85 Mich. 144, said similarly:

"The statute was not intended by the legislature to apply to service or employment such as the hiring by the week, month or year."

It does not follow that such a rule will be applied to the United States statute. If so, its purpose might be defeated by hiring laborers and mechanics by the hour or week.

The laws passed by State legislature establishing a standard for a day's work under private contract always contain a provision that special agreements may be made for a different number of hours. Such laws would be unconstitutional without this provision. Where a laborer is hired by the week or month or by the hour, these decisions hold this to be a special agreement and consequently not within the limitations of the general law. In prescribing an eight-hour law for public works of the United States, the Gov-

ernment, we have seen, is not limited by any constitutional prohibition, and the principle asserted by the courts under laws attempting to limit private contracts is not necessarily applicable.

Whether hiring by the week, month or hour would take a case out of the United Staes eight-hour law is therefore not positively settled. The chance that a decision will be rendered in the affirmative is not enough to warrant contractors in taking the risk of violation of the law by employing laborers by the week or hour and working them in excess of eight hours a day.

These references to court decisions may aid contractors to determine what employees are within the law and what outside its protection.

Emergency.—The law provides an exception to the rule of eight hours a day "in case of extraordinary emergency." What falls within this exception? Webster's dictionary defines an emergency as "any event or occasional combination of circumstances which calls for immediate action or remedy; pressing necessity; exigency." The Standard dictionary defines the word as "a sudden or unexpected occurrence or condition calling for immediate action; a perplexing and pressing combination of circumstances; sometimes less properly used in the sense of urgent need or exigency."

In a circular issued by one of the officers of the War Department this word is thus defined:

"Special attention is called to the fact that the emergency provision in the law is considered to cover any extraordinary emergencies which cannot be foreseen, such as might be necessary for saving life or property of the United States, and not cases which depend for their emergency solely upon economical methods of work or importance of rapid construction."

It is very doubtful if this limited meaning will be sustained by the courts. The definitions quoted involve two ideas; the sudden or unexpected nature of the occurrence or its pressing necessity. The existence of either of these conditions apparently creates an "emergency." Thus there would seem to be an emergency where an engineering work must be accomplished in a single season and work is limited to periods of dry weather and low water. Especially would this constitute an emergency if it were impossible to secure enough labor to permit the organization of separate eight-hour shifts of men.

The only court decision throwing light at all upon the judicial view of this question is a decision of the Appellate Division of the Supreme Court of New York in People v. Waring, 52 App. Div. 36; 64 N. Y. Supp. 865. The city of Olean had been dependent for some time upon a single pump for its water supply. It contracted for an additional pump, the purpose being to guard against "breakage or impairment of the single pump which had theretofore been the sole reliance of the city." The New York statute forbade work in excess of eight hours except in case of "extraordinary emergency caused by fire, flood, or danger to life or property." The court said that the need of putting in a second pump was such an emergency, discussing the subject in the following language:

"We are of the opinion that the emergency which presented itself to the respondents at the time when it is claimed that the law was violated was one which justified them in making extraordinary exertions to complete the work which they had undertaken. Olean is a city of considerable size and importance. Its inhabitants were dependent upon the city water-works for their water supply, and they consumed a million and a quarter gallons of water per day. In order to supply this large quantity of water, it was necessary to keep the one pump then in use in almost continuous operation. Consequently it may be readily seen that had any accident happened to this pump, as was liable to be the case at any time, the most serious consequences must have ensued—consequences which would have proved disastrous to all classes of the community, rich and poor, employer and employee. Surely in these circumstances it was not only proper, but it was plainly the duty of the officers having the matter in charge to take extraordinary precaution to avert such a calamity, and inasmuch as it is not pretended that they wilfully or intentionally violated the law, we think the case so far as this particular feature of it is concerned may be dismissed without further comment."

This decision is thus at variance with the construction placed upon the law by the engineer officer whose circular has been quoted.

Rulings on the Law.—It would be of great value to the practical administration of the eight-hour law that here should be some authority to define in advance its meaning so as to protect the contractors who wish bona fide to obey the law. Unfortunately there is no way in which the law can thus be interpreted.

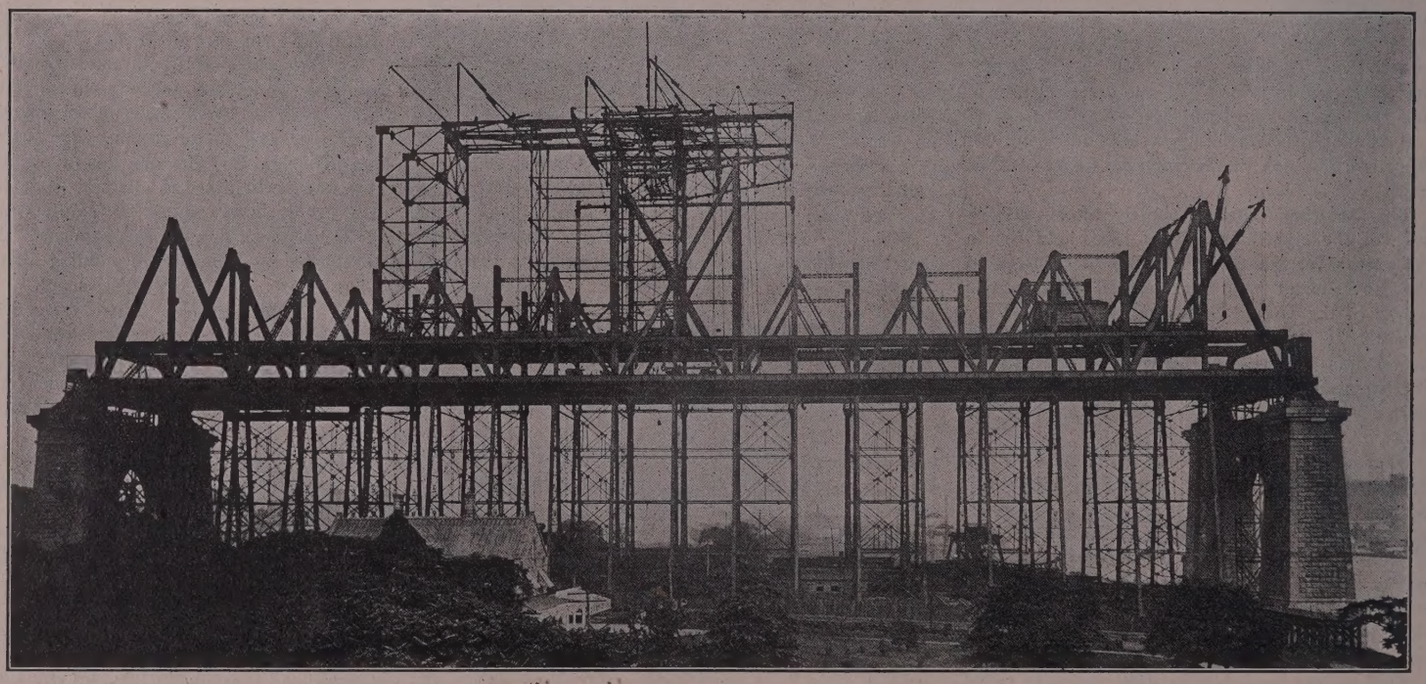
The Attorney General was asked by the heads of departments, shortly after this law passed, for an advance opinion as to its meaning, so that the contractors might be instructed in regard to it (20 Op. 463, 465). He declined to render any opinion until some actual case should arise.

The writer personally called upon the officer of the Government immediately concerned with the execution of large public works, and was told by him that no such advance definition would be attempted, but that the contractors must exercise their own best judgment in keeping within the law.

The examination of the decisions interpreting this law as here given may not be completely exhaustive, but it covers practically all the points of immediate interest upon which authoritative decisions have been made. A valuable discussion of this subject is found in a note to 65 L. R. A. 33. The discussion is submitted to the contractors in the hope that it may be of some practical value to them in determining their course under this most embarrassing statute.

New Dock on the East Coast of England.

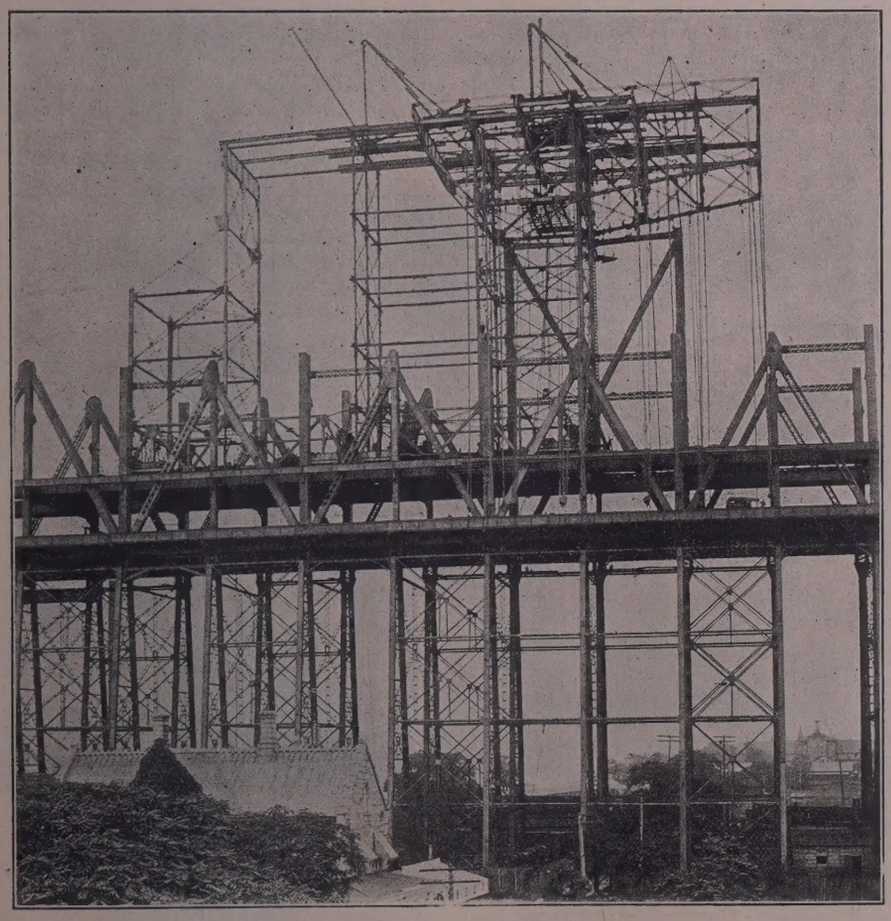
A dock has just been put under construction at Grimsby on the east coast of England, which will be capable of accommodating the largest vessels afloat. The new dock, when finished, will be 1,100 ft. square, with a bay or arm, 1,250 ft. long by 375 ft. wide, at the southwest corner. The main dock and arm will have an area of 38½ acres of water. Provision is made for future developments of three other bays, or arms, at the corners, bringing the total dock area to 71 acres of deep water. There will be 6,760 ft. of quay space in the main dock, which will be brought up to 14,110 ft. when the four bays are completed. In all, 616 acres have been acquired for the dock, of which 79 acres will be water space, and the remaining 537 acres for land about the dock when completed. The depth of water in the dock will be 35½ ft. below high water at spring tides and 32 ft. below high water at ordinary neap tides. The entrance lock, which is to be funnel-shaped, will be 850 ft. long and 90 ft. wide, with 28 ft. at low tides. Vessels of deep draft will be able to enter or leave at any state of the tide.



Second Position of Derrick Erecting No. 2 Traveler, Blackwell's Island Bridge.

Progress on the Blackwell's Island Bridge.

The erection of the super-structure for the island span of the Blackwell's Island Bridge across the East River at New York City, has now entered on the third stage, and is at an interesting period where many of the characteristic features of the method and most of the typical portions of the structure are visible and all parts of the island erection plant are in service. The design of the bridge and the general system of erection and plant installed have been fully described in previous issues of The Engineering Record, from which it will be remembered that the island span, 630 ft. long with trusses, 118 ft. deep in the center, and 185 ft. deep at the ends and 60 ft. apart on centers must be completed to serve as an anchor before the commencement of the first cantilever arms of the channel spans. The latter are 984 ft. and 1,182 ft. in length, and with the 459 and 469½-ft. shore spans make up the structure, 3,724½ ft. long between approaches, which contains about 100,000,000 lb of steel. It is a double-deck structure, with six lines of track, one carriage way and two sidewalks, and has a total estimated capacity of 150,000,000 car passengers per annum. Provision is made for two additional lines of track, whenever the traffic is sufficient to warrant their construction.



Commencing Erection of Second No. 2 Traveler, First Position of Derrick.

The sub-structure has been entirely completed for the five main spans, of which the center island span and two shore spans are to be erected on falsework and serve as anchor arms from which the main spans would be erected by the cantilever method. The permanent structure has been designed with special reference to the erection requirements, and the contractors have made elaborate preparations for all of these requirements. Although longer than any cantilever spans yet completed on this continent, the channel spans are not as long as that of the Quebec Bridge now under construction, but the trusses are relatively shallower and the live load greater, so that the chords have a much larger cross section than any heretofore attempted. These great weights and dimensions together with the height of the bridge and the character of the river crossings involved difficulties in the erection which have not previously been met, and the preparation for them and the solution of the ercetion problems developed a large amount of special construction and new methods of great interest which not only appear to indicate the practical limits of such structures with present facilities, but also point with equal value to a new era of bridge erection in which there is much modification of former methods, a considerable amount of special plant, novel appliances and an almost universal application of power from a central plant to perform field operations.

All members of the superstructure are shipped complete to the site from the steel plants in which they have been fabricated, many of them on special cars or groups of cars. They are delivered on floats, and all material for the island span and for one-half of each of the cantilever spans, about 25,000 tons in all, will be landed at a special wharf built by the contractors on the west side of Blackwell's Island, where it is unloaded by a large steel boom derrick with a capacity of over 65 tons, which places it on flat cars running to the storage yard parallel with and near the bridge axis. Here it is unloaded, assorted and piled by two electric traveling gantry cranes that also reload it on surface cars, which deliver it to the bridge. The power plant adjacent to the storage yard is equipped with a 480-h.-p. battery of boilers furnishing steam for the operation of the electric and compressed air installations which distribute power over that part of the work between the centers of the two channel spans. Power will be transmitted electrically to both sides of the river for use in the erection of the shore spans and shore arms of the cantilever spans of the bridge.

The island span is erected on falsework about 115 ft. high, consisting of four-legged braced tower bents at each panel point, weighing in all about 1,700 tons. It is assembled in the field with surface bolts instead of rivets to facilitate its removal and re-erection for the support of the shore spans. The falsework was described in the issue of this journal of March 18, 1905, and the method of its erection was described and pictures showing the details were published in the issues of Feb. 24 and March 3, 1906.

The erection of the falsework marked the completion of the first stage in the erection of the island span. The second stage was the erection of the lower half of the super-structure which weighed about 11,000,000 lb., and included both decks, the lower lateral systems and the trusses up to the center point where all of the web members are spliced to facilitate erection, reduce the lengths of members and enable the erection to be accomplished in two successive operations. This part of the work was handled as already described by a single steel traveler known as traveler No. 1, which was illustrated in The Engineering Record of March 11, 1905. It is of very simple construction, consisting essentially of a horizontal rolling platform about 41 ft. square, with vertical masts at the two front corners which are rigged with 85-ft. steel booms of 65 tons capacity. The traveler weighs about 200 tons, the derricks weigh about 45 tons each, and the hoisting engines 63,000 lb. each, so that together with tackles and other equipment the complete traveler has an estimated weight of about 400 tons. The topping lift and hoisting tackles are rove with 13 parts and 11 parts respectively of ⅞-in. steel cable, and are operated by two 3-drum, 6-spool hoisting engines, served by 100-h.-p. boilers. When in service the travelers are jacked up off the wheel base and are anchored by vertical rods and clamps engaging the floor beams and stringers.

The traveler commenced at pier two, and moved forward for the successive operations, always stopping with its front wheels resting on the last sub-panel point floor beam erected, and erecting one complete panel in each position. The bottom chords were first assembled, then the vertical posts, diagonals and lower and upper floor systems in sequence. The permanent lower chord pins were driven and the pin holes in the center of the trusses were temporarily filled with wooden pins somewhat smaller in diameter than the permanent pins, and serve to connect the members loosely until the other pieces at these points are assembled and the final connection can be made.

The upper parts of the trusses of this span, together with the sway bracing and top laterals weigh about 6,400,000 lb., and their erection constitutes the third stage of the erection of the island span. It is being effected by the two No. 2 derricks which were described and illustrated in The Engineering Record of March 18, 1905. These travelers are duplicates, each of them having a Z-shaped side elevation made with a 36x40.5-ft. steel tower 120 ft. high, with the base extending to the rear an additional 50 ft. to balance cantilever trusses at the top with an overhang of 63 ft. in front of the tower. The traveler alone weighs about 400 tons, is mounted on two special four-wheel and two eight-wheel trucks and with its equipment has an estimated total weight of about 500 tons.

In the center of the transverse girder at the top of the forward bent of the traveler will be seated the 60-ft. mast of a steel derrick with a 75-ft., 65-ton boom. This derrick has not yet been erected, but the two wooden derricks with 10-ton, 55-ft. booms, which it will supplement, have been erected and are now in opera-

tion, one of them being rigged with the steel cable tackles destined for ultimate use with the steel derrick.

The total number of tackles used on traveler No. 2, is thirty-four, in addition to those required for the derricks. All of them, except two 11 and 13-part steel tackles are rove with Manila rope up to 2-in. in diameter and have capacities of 10 to 40 tons each. Those not required for the derricks are suspended directly from five lines of longitudinal jigger beams, one line in the plane of each truss, one line in the plane of each material track laid on the cantilever projections of the lower deck floor beams, and one line in the axis of the bridge. The jigger beams are pairs of parallel girders with movable transverse plates on the top and bottom flanges connected by screwed hooks receiving the tackles. Whenever it is necessary to shift the position of the tackle, it is quickly accomplished by loosening the screw and moving the hook and plates back and forth on the girders. Each traveler has powerful hydraulic jacks and heavy clamps to secure it to the stringers when in service. It is equipped with two special hoisting engines together provided with three drums and fourteen spools and seated with their boilers and supplies on the rear extension of the traveler to serve as a partial counterweight for the loads suspended from the overhead cantilever. The traveler requires a crew of about 60 men to operate it and assemble and connect the members handled by it. The estimated weight of the traveler and equipment is about 500 tons and it is designed to move between the trusses in advance of the assembling of the transverse bracing which obstructs the passage so that the traveler cannot return after having passed a given position.

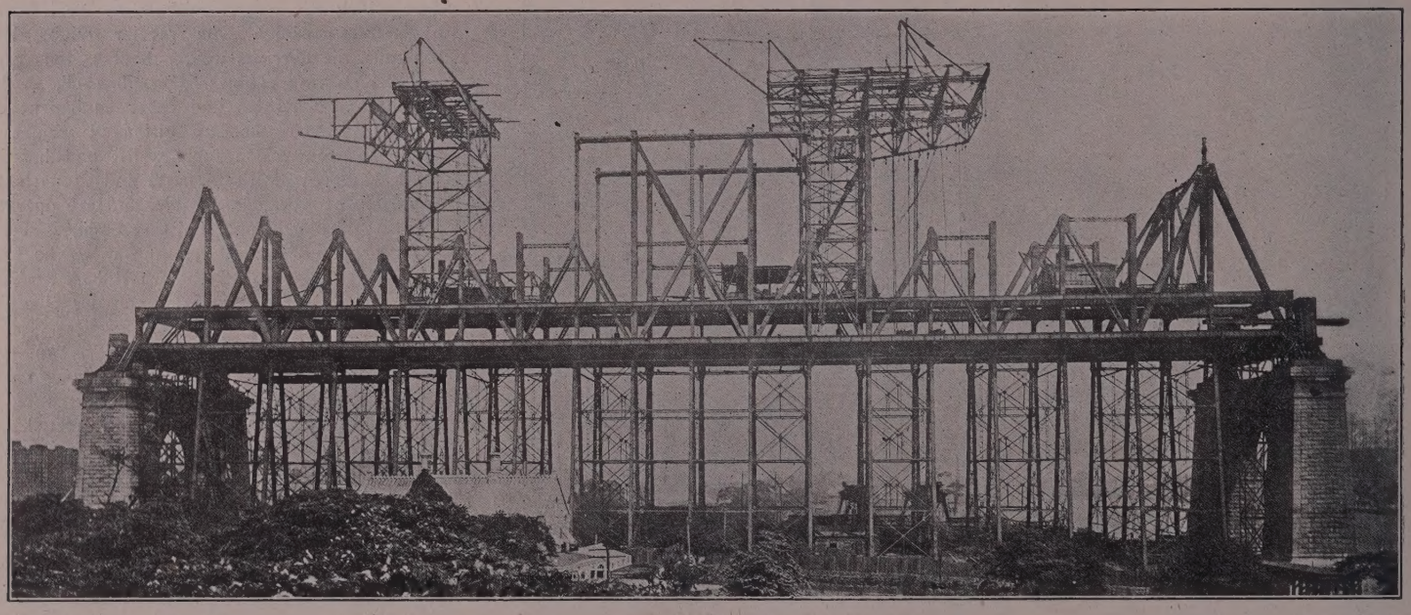
The first traveler was erected by derrick booms carried up on its vertical posts as the latter were extended from story to story. After the tower was completed the front and rear upper cantilever trusses and brackets were assembled on it by the wooden derricks shown in the accompanying progress photographs. After the first traveler was erected, the rear derrick built a transverse timber vertical bent seated on the rear of the traveler. This was temporarily braced to the traveler with horizontal longitudinal timbers at every story and thus formed a light temporary tower on which the derrick was moved to a new position on the cap of the bent and there commenced the erection of the tower for the second No. 2 traveler. Meantime the first No. 2 traveler commenced at panel point 64, near the center of the span, the erection of the upper parts of the trusses, completing two panels from the first position. When these were finished, the second tower of the No. 2 traveler was completed and independently stable so that the first No. 2 traveler could be advanced toward pier III, and continue the erection of the trusses as shown in the photograph, while the erection of second No. 2 traveler was completed by wooden derricks on top. As soon as this traveler is ready for service it will move away from the other traveler, toward pier II, completing the west end of the span, and afterwards both travelers will continue, passing the piers and erecting the cantilever arms of the channel spans out to their middle points where the travelers will be taken down and their members moved to the opposite sides of the river to be re-erected in New York and Long Island City, for the completion of the cantilever arms. In this part of the work, the travelers will assemble the complete panels of the truss at a single operation instead of accomplishing it in upper and lower halves as has been described for the channel span.

The material stored for the Blackwell's Island Bridge is in charge of a foreman who assorts it, piles it so as to be accessible when required, and delivers the members to the bridge site in the proper relative position and sequence. All members are carefully inspected by him and everything prepared so far as possible in the yard for their erection. They are loaded by the gantry on the surface cars in such a manner that they can be swung to position without difficulty by the traveler derricks, and to them are connected various special attachments by which they can be quickly and safely handled by the hoisting tackle. These attachments are of various designs corresponding to different members and are made with loops, clamps and pivots so as to allow the member to assume the necessary vertical horizontal or inclined position without producing eccentric stress, and so as to afford rapid, safe and positive attachment to the hoisting tackle by means of locked shackles.

The maximum top chord section has twenty 16x2⅛-in. eye-bars 46 ft. 6⅛ in. long bored to a clearance of 1/32 in. on the pins. Some of the pins are nearly 10 ft. long and engage about an equal number of bars from the adjacent panels and with the webs of the vertical and incline posts make very large and elaborate connections. If the eye-bars were separately assembled it would not only involve great delay in connecting them, but it would be very difficult to hold the comparatively long and flexible pieces in position. The expedient has therefore been adopted of assembling six or eight of the bars in their relative positions on the ground in the storage yard. Here they are packed with fillers and rigidly clamped together with yokes and screws and lifting frames attached by which the whole set is handled as a unit and is erected with as much ease and expedition as a riveted member of the same dimensions.

At the center of the island span members are hoisted from the ground by a special 65-ton steel derrick seated on the upper deck with its mast in the axis of the bridge. The gantries in the storage yard run parallel to the bridge trusses and so close to their planes that they deliver members for the adjacent or north truss directly to the derrick boom which receives them, hoists them to the lower deck and delivers them to service cars running on tracks laid on the cantilever extensions of the lower floor beams by which they are distributed wherever required throughout the length of the span. Members for the south truss are delivered by the yard gantry to service cars on a short surface track transverse to the bridge axis. These cars carry them to the opposite side of the bridge where they are hoisted by the derrick and transferred to their destinations as required, no members being stored on the span or falsework, except as necessary to allow the single derrick to keep up with the erection demands by working if necessary after the travelers have finished their day's work. The travelers receive the truss members directly from the cars on the cantilevered service track from which they are ordinarily lifted by two tackles, one of them suspended from the jigger beams over the track and the other from the jigger beams in the plane of the truss. The two tackles are about 8 ft. apart transversely and by operating them together the members are fleeted over to the required position at the same time that they are hoisted.

When the erection was planned and the plant to carry it on designed, it was anticipated that difficulty might be experienced in driving the unprecedentedly long and heavy pins, some of which weigh over three tons each. Provisions were therefore made for driving them, if necessary, with a special hydro-pneumatic ram intended to force them in without impact by a powerful pressure. This machine has been built, but so far it has not been found necessary to use it, as the nature of the design and the accuracy of the shop work enables the pins to be driven in the



Completion of Erection of No. 2 Traveler, Derrick in Third Position.

ordinary manner by a heavy suspended ram operated by a number of men on a platform suspended from the traveler or from one of its derrick booms.

The height of the traveler is sufficient for assembling all of the truss members up to the panels adjacent to the piers. Here the top chords and the upper sections of the vertical and inclined posts will be handled by the steel derricks and the upper transverse struts can be assembled to brace the pier bent and still afford clearance for the traveler to pass under them. The heaviest members of the trusses are 104 ft. 3½ in. long and weigh 78 tons each; these are the lower parts of the diagonals in the panels adjacent to piers two and three, and were handled by the booms of the No. 1 derrick. All of the members required for the island span and part of that for the adjacent arms of the channel spans have been completed at the shops and about 16,000 tons have been shipped to the site, as much as could be stored in the yards. The total amount erected August 25, was 7,700 tons. The present force consists of about 200 men all told.

A New Ore Thawing Plant.

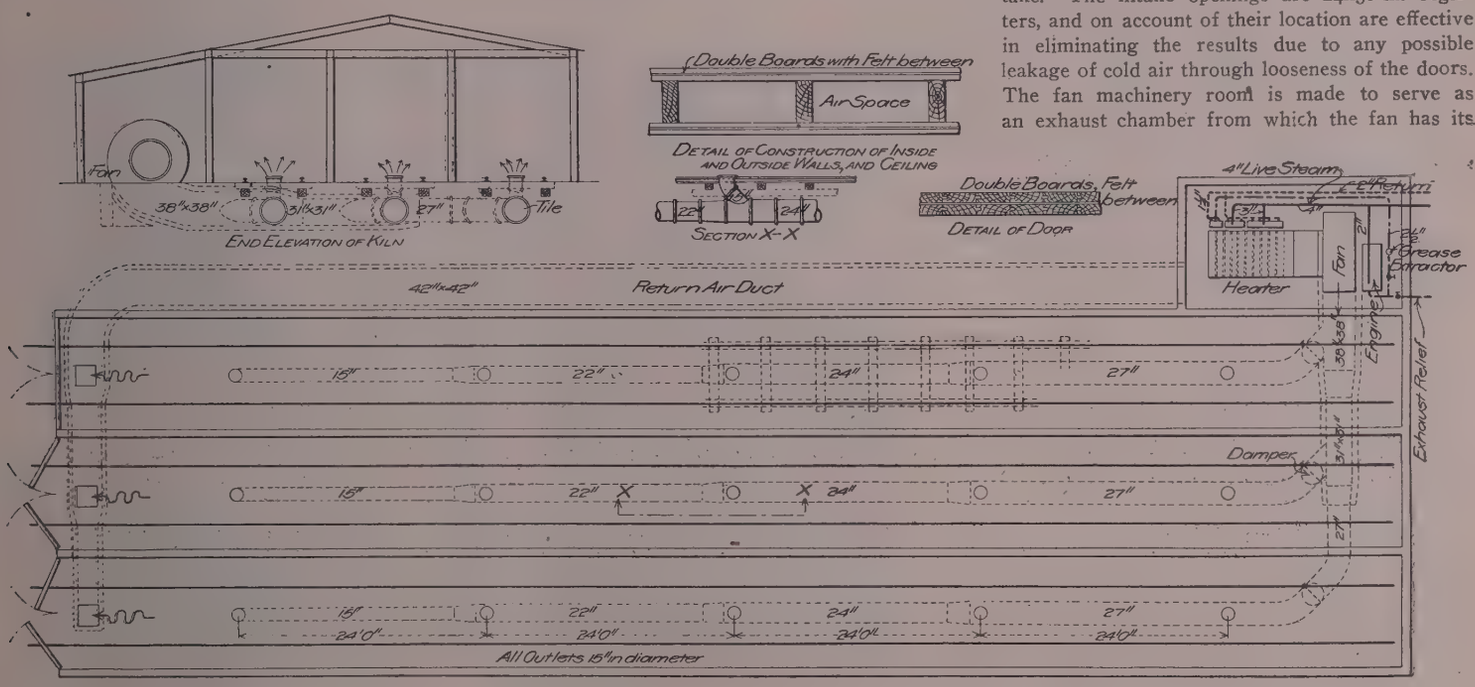
In the handling of iron ore in the Michigan and Minnesota mining districts, difficulty is frequently experienced in periods of cold weather due to the freezing of the ore in solid masses in cars. This freezing prevents the ore being dumped readily at the blast furnaces or shipping docks, and entails considerable expense and loss of time in thawing by steam from a hose. The ore is, in the fall and spring, usually wet enough when mined, or after being loaded into the ore cars, rain or snow falling upon it may add sufficient moisture to cause it to freeze solid. The usual method of thawing the ore to permit the dumping doors of the cars to open, has been the use of steam jets applied to the under sides of the dumping cars. That, however, is a very slow and inefficient process, and entails the objection that more moisture is added to the mass of ore to assist in subsequent freezing.

In order to eliminate the disadvantage of steam thawing, the Zenith Furnace Co., of Duluth, Minn., has recently installed a new kiln thawing equipment by means of which frozen cars of ore may be quickly and economically thawed out for dumping by being heated in a closed building. The kiln consists of a three-section building, each section containing a storage track, into which fifteen ore cars may be run and enclosed. A hot blast heating equipment of large capacity is used for maintaining the temperature in the building at such a point that rapid thawing will take place. The building is a frame structure, 140 ft. long by 40 ft. wide, with 12 ft. clear head room over the tracks, and is divided lengthwise into three compartments, each containing a track which will accommodate five ore cars. The building embodies the special construction, usual in lumber kilns, for heat insulation, the outside finish consisting of double sheathing with a layer of felt between the boards, while the inside, as well as the partitions between the three compartments are sheathed tight with matched lumber. In the construction of the building every precaution was taken to make all parts air-tight to prevent loss of heat in thawing.

The hot blast equipment for the kilns is housed in a 12x22-ft. lean-to at the rear corner of the building, from which delivery duct connections are made to the various sections underground. The equipment consists of a 6-ft. steel-plate centrifugal exhaust fan which draws air through a bank of heating stacks and delivers it directly through the underground system of distributing ducts. The fan is driven by a direct-connected horizontal steam engine, the exhaust from which is utilized in the heating coils. The heater consists of ten sections of pipe coils, two of which sections are supplied with exhaust steam from the fan engine, while the remaining eight are supplied with live steam at 60 lb. pressure, from the boiler plant of the company from which the engine is operated. The sections are controlled in three groups, one of two sections for the exhaust steam supplied from the engine, and the two others of three and five sections respectively for the high-pressure supply. This permits a range of adjustment sufficient for all different weather conditions encountered.

The air in the kiln building is re-circulated, the fan taking its suction through a return air duct, 42 in. square, leading from three intake openings in the floor near the entering doors, along one side of the building to the fan intake. The intake openings are 24x36-in. registers, and on account of their location are effective in eliminating the results due to any possible leakage of cold air through looseness of the doors. The fan machinery room is made to serve as an exhaust chamber from which the fan has its intake through the heating stacks. The fan delivers into an underground brick duct, 38 in. square, over which it is mounted for downward delivery, as shown in the cross-section of the building; from this point, the duct runs crosswise of the building at the rear end, and supplies branch ducts of tile piping, 27 in. in diameter, laid under each of the three compartments. Each of these branch lines has five 15-in. outlet connections projecting up through the floor, which openings are so distributed as to come underneath the middle points of the ore cars when placed in the building. Each branch duct has a damper, so that delivery may be shut off from any of the compartments, as may be necessary for removal of the cars, without in any way interfering with the thawing operation in the remaining compartments.

The equipment is designed so as to be capable of raising the temperature in all three of the compartments and maintaining it at such a point that the ore frozen solid under the worst conditions in fifteen cars may be entirely thawed out in a course of 20 hr. This provides for a daily capacity of fifteen carloads of ore, amounting to approximately 450 tons. A considerable



Details of the Kiln Building for Thawing Cars of Frozen Ore.

The bridge was designed and is being erected under the direction of the department of bridges, of New York City, Mr. J. W. Stevenson, commissioner; Mr. C. M. Ingersoll, Jr., chief engineer; Mr. O. F. Nichols, consulting engineer, and J. A. Knighton, resident engineer. The contract for the manufacture and erection of the superstructure was awarded to the Pennsylvania Steel Co., Mr. J. V. W. Reynders, vice-president; Mr. Thomas Earle, superintendent of bridge and construction department; Mr. Fred W. Cohen, engineer of erection; Mr. L. N. Gross, general foreman of erection, and Mr. Buchan, assistant general foreman of erection.

AN EXPERIMENTAL GAS TURBINE has recently been constructed in France, which under test showed an efficiency of 18 per cent. The turbine is of the impulse type, with the casing lined with refractory material. Gasoline is used as fuel, and is fed under pressure through an expanding nozzle, being ignited electrically and generating a temperature of combustion of over 3,000° Fahr. The blades were cooled to a certain extent, while rotating by low-pressure steam admitted into the casing.

saving in time is effected over the usual process of thawing by steam jets and the uncertainty and high labor costs pertaining to the latter are eliminated. The effectiveness of this system is due primarily to the fact that the hot blast is delivered directly upward beneath the dumping doors of the ore cars, at which points the rain water or melted snow in the ore accumulates and freezes solid, and which, owing to its inaccessibility, is very difficult to thaw by the steam-jet method. The hot-blast method of thawing not only prevents the addition of further moisture to the ore, but is effective in removing a large portion, which is a decided advantage for ore that is to be charged directly into the blast furnace.

This kiln plant and its equipment of blower and heating stacks were designed and installed by the Buffalo Forge Co., Buffalo, N. Y.

The Detroit Tunnel of the New York Central Lines.

The contract for the construction of the twin railway tunnels to be built under the Detroit River from Detroit, Mich., to Windsor, Canada, for the New York Central lines was awarded last week to Butler-Bros.-Hoff Co., of New York City. A complete illustrated description of the tunnel project and the three plans offered by the advisory board of engineers, Messrs. W. J. Wilgus, H. A. Carson and W. S. Kinnear, as a basis for construction proposals appeared in The Engineering Record for Feb. 17, last. The tunnel is to be built according to a modification of the plan submitted at that time by Mr. Wilgus, who is vice-president of the New York Central & Hudson River R. R. and chairman of the advisory board.

Mr. Wilgus' plan is a trench method involving a departure in subaqueous tunneling. The general features of this plan were fully presented in the previous description to which reference has been made, so only the added details of the final, modified plan that have just been made public need to be explained now. In accordance with this plan, before sections of the steel tunnel tubes are floated into place, and immediately after the dredging for the section has been completed, piles are to be driven in the bottom of the dredged channel and cut off at the proper height (or an inch or so below to permit shimming). These piles are to be capped with steel beams to receive the tubes. When the piles are driven, the bottom of the channel to the level of the top of the beams is to be filled with a layer of material of suitable consistency and bearing power, from 12 to 18 in. in thickness or as much more as may be necessary to fill in holes or depressions left in the bottom of the trench by the dredging operations. This layer will form a blanket between the bottom of the trench and the concrete to be deposited around the steel tubes. Sand and gravel will be used for this layer with the addition of cement where necessary.

Tubes of plate steel ⅜ in. thick and weighing an average of 15.3 lb. per square foot will be sunk in the trench on the steel beams and the bed of gravel and concrete. The steel tubes will be built in lengths of 263 ft., or in such lengths as are found most convenient to handle. The plates will be lap-jointed with a double row of ¾-in. diameter rivets, the outside edges being beveled and caulked so as to be absolutely watertight. The steel tubes are to be reinforced on the outside about every 12 ft. by diaphragms which will serve the purpose of a cradle in sinking the tubes to their permanent position. On the inside, midway between the diaphragms, the tubes are to be reinforced with a stiffened angle to which will be attached temporarily, radial rods of 1-in. diameter, though these rods may be dispensed with if it shall be found that they are not needed. The ends of the tubes are to be reinforced with similar radial rods to prevent deformation during handling. The steel in the tubes is to be of the grade of railway bridge steel, with an ultimate tensile strength of 55,000 to 65,000 lb. per square inch.

The tubes will be sunk separately or in pairs from scows properly anchored for the purpose or from temporary platforms supported on piling. The greatest care will be exercised to see that they are not overstrained in the handling so as to cause leaks in the joints. When in position to be sunk the tubes will be lowered in a slow and careful manner so as always to be in complete control. The piles in the trench will always be in such positions that one of the diaphragms of the tube will rest upon the beam when the tubes are in place. Each tube or pair of tubes is to be provided with a detachable upright at each end firmly braced to the tube and of sufficient length to indicate the position of the tube when sinking. These uprights will also serve the purpose after the tube is sunk to adjust its position laterally, so as to bring the sections into alignment. The uprights will, therefore, extend 10 ft. above the water after the tube is in position. When the tubes are concreted in, these uprights will be removed and used again. When the tubes are adjusted laterally to their correct position divers will examine all bearings of the tubes on the beams in the bottom of the trench and will insert shim plates of proper thickness to produce exact bearings.

Each tube when manufactured will be fitted with a sleeve at one end which can slip over the end of the adjoining tube previously sunk. The sleeve is to be provided with a flange which can be bolted to a corresponding flange of the adjoining tube, a rubber gasket being placed between the two. A similar rubber gasket is to be provided at the inner end of the sleeve bearing up against the edge of the next tube. In bolting up the flanges, which must be done by divers, the rubber gaskets must be squeezed together between the ends of the tubes to form a tight joint. A 3x18-in. space is thus formed all around the tube at the joint. This space will be filled with a grout of pure cement. To facilitate this filling each sleeve will be provided on top with two small pipes (flexible pipes and joints) leading to the scow floating above. Each joint will be tested with a force pump to ascertain whether it is tight by closing one pipe and forcing water through the other. When the joint has been made reasonably tight pure cement grout will be pumped into it through one pipe until it comes out through the other as evidence that it is completely filled.

In order to assist in making an exact connection between the tubes each tube will be provided with two pilot pins with taper points that fit into bell-shaped sockets fastened to the adjoining tube. When the tubes are sunk and pulled into place these pilot pins will guide the tube to its exact position for making connections. Before each tube or set of tubes is launched the corresponding end of the next tube will be fabricated and all flanges, rubber gaskets, bolts and pilot pins with sockets, fitted together, so that when connected up they will fit accurately.

The ends of the tubes at the joints are further to be fitted with flange angles on the inside for the purpose of caulking between them should the joints be found to leak. These flange angles are then to be connected with bolts drawn up tight and a suitable caulking material forced in between such angles to make the joint tight. These angles will not be connected where the joints are found tight and acceptable.

A wooden form is to be bolted in the outer flanges of the diaphragms of each pair of tubes in order to confine the concrete deposit around the latter. This form is to consist of rough planks of yellow pine, white pine, spruce or other timber, 3 in. thick and 8 to 12 in. wide, securely bolted to the flanges of the diaphragm with ⅝-in. bolts. The form is to be finished on top with a string piece. In the preparation of the concrete for the tunnel filling it is provided that gravel may be used in place of crushed stone.

In order to enable the contractors to begin lining the tubes before the sections are sunk all the way across the river, some of the tubes may be provided with bulkheads to keep out the water when the tubes laid are being pumped out. Such bulkheads will necessarily be of ample strength to take the full hydrostatic pressure coming upon them. A common sump for two tubes or a separate sump for each tube will be constructed complete with sump chamber and work incidental thereto.

Laying a Submerged Water Main.

A 15-in. water main was recently laid under the Ouse River at York, England, from a heavy cableway strung across the stream. A series of locks downstream from the pipe crossing maintains a somewhat uniform depth of water at low flows in the river, the low-water depth being 9 ft. at the crossing. As the river was to be lowered somewhat for a week by opening the locks, the work was planned to carry on the most difficult portions of it while the water was low. A trench was first dredged across the river, as cofferdams could not be built. Mr. W. H. Humphreys, water engineer of York, in describing the work before the British Association of Water Engineers, said it would have been desirable to have secured a greater depth in this trench, but the nature of the river bottom and the difficulty of maintaining the dredge on the line of the pipe trench owing to floods prevented the completion of the additional excavation prior to the time for lowering the river.

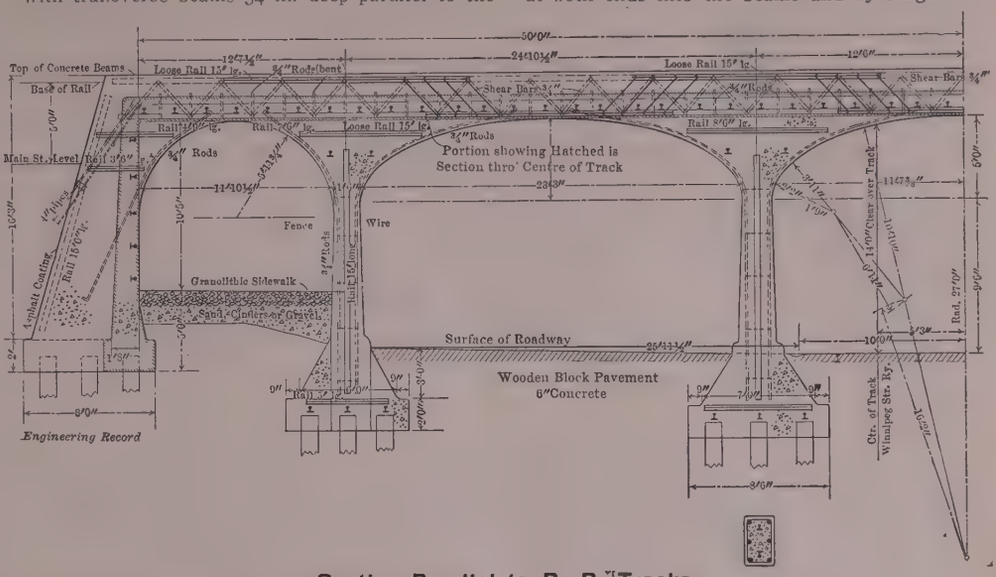
Hub and spigot cast-iron pipe in 12-ft. 1-in. lengths, with a wrought-iron hoop shrunk on at the sockets, was used. The pipe weighed 1,850 lb. per length, and was double-coated with Angus Smith solution. Five ball-and-socket joints, made perfectly tight at any angle under a pressure of 300 lb., were required to permit the main to assume the profile of the river bed when laid.

The cableway was anchored to two piles on each bank of the stream, with a third pile at each anchorage to guide it. At the time the laying was done the width of the river had been reduced to 100 ft., so that eight 12-ft. lengths of pipe with the ball-and-socket joints were enough to cross it. The alternate joints were made with ball and socket. A lead joint between two lengths of pipe was first made and half of a ball-and-socket joint attached to each end of this two-length section. This section was then swung in chains rove in blocks on the cableway and hauled across the river. It was then lowered nearly to position on the bottom of the river between two barges held 8 ft. apart, one upstream and one downstream from the trench, and its weight transferred to these barges. A second two-length section was then made, pulled across the stream and its weight also transferred to the barges after the ball-and-socket joint between the two sections had been made. A third two-length section after being run out and lowered was suspended on the cableway while the fourth and last two-length section was held by a derrick on the bank. When the joints had been inspected, the trench was cleaned out and the eight joined lengths lowered simultaneously with chains in the blocks from which they were supported. One of the eight-length sections was held above the water by the cable and the other by a derrick until connections could be made with the pipe line on each side of the river. The ball and socket joints had to be lowered about 9 in. afterward by a diver.

An Eight-Track Reinforced-Concrete Viaduct in Winnipeg, Manitoba.

Eight tracks of the Canadian Pacific R. R. cross Main St., Winnipeg, Manitoba, overhead at an angle of 86 deg. 4 min. on a reinforced-concrete structure, which is of interest both on account of the special design of the concrete groined arches in it and from the character of the reinforcement, which consists of scrap rails bolted and trussed together to resist stress in flexure, tension and shear. The small depths of the arch crowns is noteworthy, especially in consideration of the fact that the tracks are carried over them in ballasted troughs.

The railroad tracks occupy the full width of Point Douglass Ave. and were raised 5 ft. above their former grade in order to secure a maximum clearance of 14 ft. over the two electric car tracks on Main St., and to allow the latter to remain above water level when they were depressed 11 ft. 11 in., thus permitting the subway to be built with a total length of 646 ft. 8 in. with approach grades of 1:20. The width of the structure is 100 ft. over all, exclusive of the stairways, and it only receives about ¾ of the original street, a strip 32 ft. wide being maintained at the original grade



Section Parallel to R. R. Tracks.

Interior of Viaduct.

east of the subway on both sides of the railroad tracks, but not being carried across them. The structure consists of an east and west approach, with concrete retaining walls parallel to Main St. and an arched center portion, 140 ft: long, which is here illustrated and which forms a continuous bridge floor, supported as indicated in the plan, by four rows of 11 columns and abutments each.

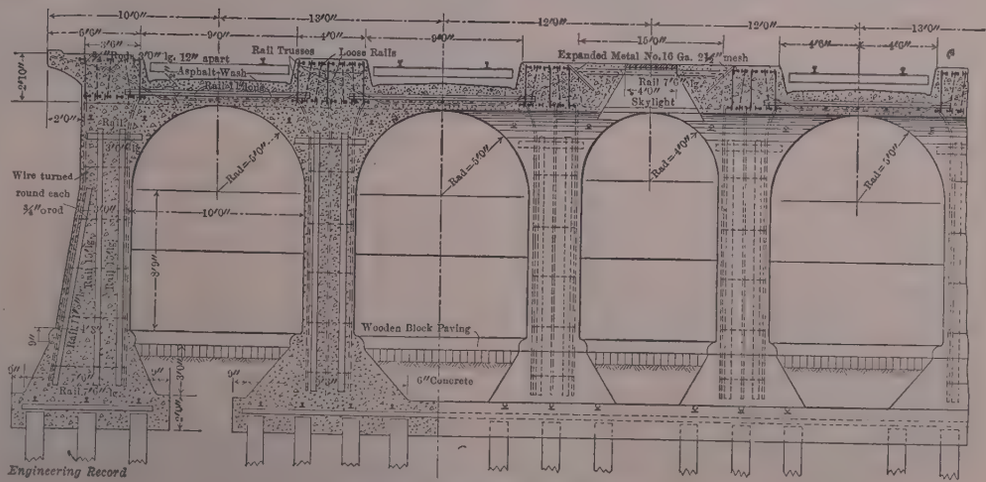
The principal arches have their axes parallel with Main St. and are arranged in 5 spans. A 23-ft. 3-in. center span over the double-track electric street railway is flanked by two 23-ft. 3-in. similar spans over the driveways and two 11-ft. 10½-in. full-centered spans over the sidewalks. The large spans are false ellipses made with seven centers each, and are relieved in elevation by triangular panels 1½ in. deep over spandrels which serve also to define the extrados.

The curves of the intrados are described with radii of 2 ft. 2 in., 3 ft. 11 in., 10 ft. 10 in. and 27 ft., the rise being 5 ft. The main arches are shown in the general view of the exterior of the bridge. A view at right angles to this, showing an elevation at right angles to the railroad tracks, is given in the general cross-section, which also serves as a longitudinal view of the structure.

The tops of the columns or piers are integral with transverse beams 34 in. deep parallel to the railroad tracks and reinforced by trusses made with rails embedded in the concrete near the upper and lower surfaces of the arches and latticed together. The beams are connected and the ballast is carried by concrete slabs 18 in. thick at the center whence they are pitched both ways for drainage, and are reinforced by rails projecting at both ends into the beams and by longitudinal transverse round rods, the latter bent upwards at the ends and continuous across the main beams on the center lines of each to intersect the corresponding rods from adjacent panels. The under sides of the slabs and beams have concave surfaces forming the soffits of the groined arches.

Between the tracks are two 15-ft. platforms and one 9-ft. platform, each built with top and bottom slabs with an air space between, and pierced with skylights made removable so as to provide for the distribution of snow on the roadway below if necessary. The upper platform slabs are reinforced with expanded metal and are 6 in. thick for a 15-ft. platform and 4 in. thick for a 9-ft. platform. The lower slabs are 3 in. thick at the arch soffit, and are not reinforced. The piers or columns are vertical on the transverse faces and battered on the longitudinal faces, forming solid rectangular cross-sections from 18 by 36 in. to 21 by 36 in. at the springing line, except four piers 8 ft. wide with chambers 3 ft. wide filled with 1:4:7 concrete and four other special piers 5 ft. wide without chambers.

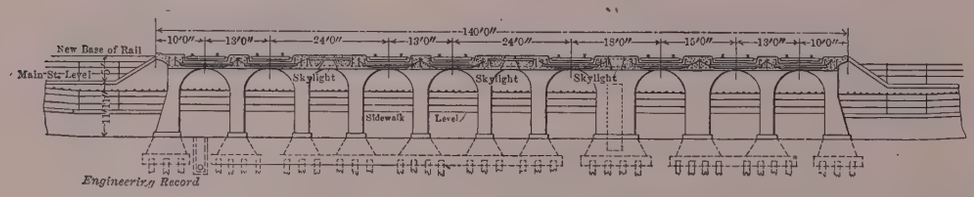
The column shafts are made integral with expanded bases battered about 1:1 on both sides to widths of from 6 to 10 ft. at the bases where they unite with the continuous concrete longitudinal footings 7½ and 8½ ft. wide and 2 ft. deep. The footings are carried to a total depth of 5 ft. below the roadway and extend 12 in. below the tops on their triple rows of piles. They are reinforced by single longitudinal lines of rails on the centers of the piles and by an upper tier of



Section Parallel to Street.

three or four transverse rails at every pier. Each column is reinforced by two vertical rails extending from above the springing line down nearly to the top of the footing and by six vertical ¾-in. rods, one in each corner and one in the middle of each long face, tied together with horizontal wires about 3 ft. apart. The upper ends of these rods are bent parallel to the intrados of the arch and are continuous from the tops of the footings to the centers of the spans, where they are bent over the bottom chords of the trusses reinforcing the main beams. All of the corners of the columns are rounded to a radius of 2 in., and the angles at their intersection with the bases are covered by fillets joining protective mouldings, resembling the tops of buried wheel guards at pavement level.

The reinforcement trusses are made continuous across the full width of the bridge. They are 30 in. deep over all, with top and bottom chords



General Elevation Parallel to Street.

formed with single rails spliced with pairs of ordinary angle bar track splices. The heads of the rails are turned in opposite directions and their flanges in the same vertical plane, are connected by 2 x 5-16-in. lattice bars riveted on. The beams and trusses terminate in counterforts of the retaining walls, between which the wall slabs are 12 in. thick at the top and 20 in. thick at the base, and are reinforced by horizontal rails 2 ft. apart and 2 in. clear of the inner face of the wall. The counterforts are each reinforced by two rails 15 ft. long parallel with the bridge and 3 in. clear of the other face.

The beams are reinforced at points of maximum moment by loose rails 15 ft. long near the top and bottom surfaces arranged in 2, 3, 4, 5, or 6 pairs in different beams. The rails of each pair are connected by ¾-in. diagonal shear bars 15 in. apart and 3 ft. long with their ends bent to fit into holes 5 in. apart in the rail webs.

The rectangular skylights are 4x6 ft. and 4x3 ft. and are made with cast-iron frames set on rails bedded in concrete to form curbs around the skylight wells, the walls of which are bevelled 7:12 so as to diffuse light in the subway.

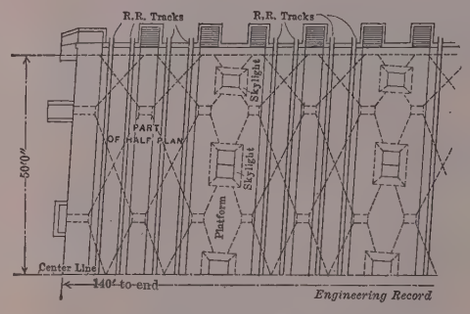
All footings and the retaining walls in the approaches were made with 1:4:7 gravel concrete. The arches above the springing line were made of 1:2:4 broken-stone concrete and the remainder of the structure was made with 1:3:5 gravel concrete. Imperial, Iron Clad, and Atlas brands of Portland cement in equal quantities constitute the 7,479 barrels used in the work. All concrete above the springing lines of the groined arches was built in sections parallel with the railway tracks on each of which the work was carried on without intermission until it was completed.

The structure was designed under the direction of Mr. E. H. McHenry, then chief engineer of the Canadian Pacific Railway Co. The preparation of the plans was supervised by Mr. C. N. Monsarrat, engineer of bridges, and Mr. J. E. Schwitzer, division engineer at Winnipeg, was in direct charge of the construction. The contract was awarded to Deeks & Deeks, Winnipeg, who commenced operations May 30, 1904. Although the work was delayed very much by wet weather up to the middle of July, it was advanced sufficiently for the first train to cross the new structure Oct. 22, and was completed in the middle of November, 1904.

Methods of Burning Small Anthracite Coal.

By E. H. Peabody.

It is a well known fact that the larger sizes of anthracite such as broken, egg, stove and even chestnut, can be handled in the boiler furnace with ease, giving excellent results, not only in economic evaporation per pound of fuel, but in amount of horse-power developed as well. No great skill in firing is required, the main requisite being to get the coal into the furnace in a fairly even bed. The relatively small amount of ash in these coals permits operating the furnaces for long periods without cleaning fires, and the cleaning is facilitated by the use of grates with wide air openings, allowing a considerable portion of the refuse to drop through the grate bars into the ash pit. Further, the draft necessary to burn the larger size coal is not excessive so that ordinary chimneys answer all requirements.



Part Top Plan.

Front Elevation of Winnipeg Viaduct.

But the greatly reduced prices of the very small sizes of anthracite now common in the market, are an ever present inducement to the owner of a steam plant to change his fuel and burn No. 2 or No. 3 buckwheat. If he can do this and at the same time maintain the necessary output of steam from his boilers this will doubtless prove to be a money-saving proposition at the prevailing prices of the large and small sizes of anthracite coal.

In making the change, however, the essential problem which confronts his engineer is, how to keep up steam with the low grade fuel. A few hours shut down or appreciable lack of capacity, may much more than offset any saving in cost of fuel effected by the use of the cheaper grade. The matter of maintaining the standard of efficiency is important, but nevertheless is always considered secondary to the question of capacity.

What special features of the problem therefore must be considered and adequately provided for in order to insure plenty of steam with the new fuel? In the first place, grate bars with narrow air spaces must be used. Pin-hole grates or bars perforated with round holes about ⅜ in. in diameter have been very successfully applied for use with small anthracite. These bars, however, have a low percentage of air space—usually less than 10 per cent., and hence are invariably used with forced draft. A grate bar of the herringbone type having air spaces ¼ in. in width is well adapted for burning buckwheat coal and is commonly used both with natural draft and forced blast. This bar generally gives a percentage of air space exceeding 30 per cent., which is entirely adequate. It is supposed by many that grate bars with air spaces aggregating 45 to 50 per cent. are necessary in order to give a sufficient air supply. These people do not stop to think about the resistance of the coal bed itself and their counsel often leads to a great waste of fuel in the ash pit, due to loss of coal which has sifted through the bars.

The second point to be considered is how much of the buckwheat coal must be burned to produce the same amount of steam generated by the large size coal. This matter involves both the questions of efficiency and the relative heat values of the two coals. More skill is required in firing the small size fuel; it must be spread lightly and evenly over the grate at frequent intervals, and the cleanings come oftener and require more time and labor; but the writer believes that a competent and careful fireman will obtain practically the same efficiency with the small as with the large size coal. As to heat value, while not strictly true for all anthracites, it is usually very nearly the case, that the heat value per pound of combustible (that is, the dry coal after deducting the refuse) is the same for all sizes. Assuming, then, that the same efficiency will be obtained, it is only necessary to determine the relative amounts of ash in the two coals in order to calculate how much more of the small size will be required. There is no royal road to this information; the character of the coal and the care with which it is mined and prepared for market greatly influence the ash and refuse present in the coal and each particular lot provides a law unto itself.

Moisture in the large sizes is an inconsiderable item, but in the small size coal, may represent a possible 8 or 10 per cent. (usually much less), and it is important when getting prices on coal to ascertain what proportion of it is water; at the same rate per ton. The buyer of anthracite coal, however, has always a ready means of testing the quality of his fuel, he needs only to determine the ash and moisture—the rest of it is combustible matter of very uniform quality.

Ordinarily, it may be considered that buckwheat coal contains twice as much ash as egg—about

in the proportion of 7 per cent. or 8 per cent. to 14 per cent. or 16 per cent. No definite limits, however, can be taken as a very safe guide. The writer has tested No. 3 buckwheat containing but little more than 10 per cent. of ash, while on the other hand he has found the ash in No. 2 buckwheat as high as 20 per cent. Each separate lot should have a special test.

The following example will serve as a basis for comparison of egg and buckwheat. Assuming the heat value per pound of combustible as 14,500 B.t.u. and 8 per cent. ash for egg and 16 per cent. ash for buckwheat, we should have as the heat value per pound of dry coal 13,340 B.t.u. for the egg and 12,180 for the buckwheat. Assuming further that 70 per cent. efficiency of boiler and furnace combined will be obtained in daily practice, the result will be an evaporation of 9.67 lb. of water from and at 212° Fahr. per pound of dry egg and a corresponding evaporation of 8.82 lb. per pound of dry buckwheat. It will therefore require 3.57 lb. of egg coal to develop one boiler horse power and 3.91 lb. of buckwheat, or nearly 10 per cent. more buckwheat, for the same amount of steam. The calculation is based on dry coal and allowance would have to be made for any difference in moisture.

Seventy per cent. efficiency may easily be exceeded by a good fireman, handling a well designed boiler and furnace; but while a great deal might be written concerning boiler efficiency, it will be sufficient for the present purposes to consider that 70 per cent. is obtained using both egg and buckwheat.

Having determined approximately the amount of buckwheat coal it will be necessary to burn under the boiler to give the necessary power, the next step is to make provisions for burning it. This can be done by increasing the draft or by increasing the grate surface, or both. The small particles of buckwheat coal present a much more dense and compact bed of fuel than do the larger sizes and in order to force the air for combustion through this bed a greater pressure or suction is required. If natural draft is to be used therefore, the height of chimney becomes a very important consideration. It would be well for the engineer to measure his draft at the boiler damper and find what is the maximum available.

It is not possible to approximate more than the actual draft required for burning buckwheat coal. It varies not only with the size, but with the style of firing and the kind and quantity of ash. Roughly, the following data will indicate the draft in inches of water at the boiler damper necessary for various rates of combustion:

	Draft.
10 lb. per square foot of grate per hour	0.30 in.
15 " " " " " " " "	0.45 in.
20 " " " " " " " "	0.70 in.
25 " " " " " " " "	1.00 in.

Suppose that previous calculations have shown that 700 lb. of buckwheat coal must be burned hourly under the boiler to give the necessary steam, and suppose that the grate surface equals 30 sq. ft. in area. Suppose also that the available draft equals six-tenths of an inch of water. The engineer can either increase the grate surface to 40 sq. ft. and burn the coal with natural draft at the rate of 17½ lb. per square foot per hour or he can increase the draft to nine-tenths by building a taller chimney or by putting in forced blast, and burn the coal on the present grate at the rate of 23⅓ lb. per square foot of grate per hour.

The nature of buckwheat anthracite is such that it can be used with very long grates,—furnaces 12 ft. in depth being not uncommon with very large boilers. The coal can readily be spread over this length of grate, and as the fire does not have to be "worked" no unusual labor is required except at the time of cleaning fires. For this purpose dumping grates are used, a long hoe being employed to pull the good coal away from the section to be dumped.

Dumping and shaking grates are nearly always useful in handling low grade anthracite coal; the dumping property being perhaps even of greater value than the shaking. With ordinary lengths of grate, however, up to 7 or 8 ft., if the fireman is required to clean out his own ashes, he is quite likely to prefer cleaning fires in the ordinary way by pulling the refuse out through the fire door into a wheelbarrow, thus entirely ignoring the dumping grate. The real value of the dumping and shaking grate consists of the facility it offers for making a quick cleaning, thus aiding in keeping up the steam pressure and saving heat by not allowing the furnace to cool off.

In the modern office building of the sky-scraper type, with chimneys 200 ft. high and over, low grade anthracite coal may readily be burned under natural draft and in sufficient quantity per square foot of grate per hour to give a good margin above rating from the boilers using ordinary ratios of heating surface to grate. In cases, however, where the chimney is 100 ft. or less, it is quite usual to use forced blast in the ash pit; sometimes induced mechanical draft being employed instead. The use of blowers has the advantage not only that tall chimneys are not needed, but that the draft is then entirely independent of weather conditions. The cost of operation and upkeep, on the contrary, are factors in favor of natural draft.

Some small anthracites have a tendency to form very bad clinker, in which case a forced draft produced by steam jets has been proved to be very efficacious. The action of the steam in passing through the fuel bed keeps the clinker soft and porous, resulting in excellent capacity and very quick, easy cleanings. This form of blast is practically indispensible with some fuels.

Centering for 50-Ft. Span at 138th St., Riverside Drive.

Recent Work on the Extension of Riverside Drive.

Riverside Drive is a beautiful boulevard following the east shore of the Hudson River north through and beyond one of the most select residence sections of Manhattan Island, New York City. A portion of it was completed several years ago and the present extension, known as sections 2, 3 and 4, extends from 135th St., north to 158th St., about 1½ miles. It has in most places a carriage road about 58 ft. wide, flanked by an 18-ft. bridle path and two 15-ft. sidewalks separated by 5-ft. strips of parking. The roadway is at an average height of 60 ft. above the adjacent tracks of the New York Central & Hudson River R. R., which lie between it and the river. On the west side the driveway is supported on a fill retained by a tall ashlar granite wall next to the railroad tracks and by a rubble wall on the opposite side which rises to a variable height above adjacent property. Several streets intersect the driveway, some of them being carried under it through handsome arch openings which, together with the stairways giving access to the sidewalks and the ornamental balustrades and balconies, diversify the appearance of the construction and afford an opportunity, which has been well utilized, for building very handsome and impressive masonry, the beauty of which is enhanced by the sweeping curves with which it follows the bends of the river.

The construction is massive and great pains have been taken to make it very firm and stable. The walls have been proportioned generally with a width equal to one-half the height and have footings consisting of a uniform bed of concrete 5 ft. thick usually carried down to solid rock or supported on rows of piles driven to hard strata. The total contract price for the three sections here mentioned is about $3,500,000 and the principal quantities involved include 55,000 yd. of granite ashlar from the Crotch Island and other quarries, in Maine, 75,000 yd. of concrete and 90,000 yd. of rubble masonry. Work was commenced in the spring of 1903, and section No. 2, at the south end of the extension, is now about 80 per cent. completed and will probably be finished in the spring of 1907. Sections No. 3 and 4 have been delayed by changes in the plan and by injunctions secured by property owners, but are now 70 per cent. completed.

The work in general conforms to high-class standards and has been executed rapidly and satisfactorily with extensive and well arranged plant described in The Engineering Record of March 25 and April 15, 1905. The equipment for section No. 2 includes a pier and derricks for unloading materials from boats, an inclined belt conveyor to deliver them to a point higher up on shore where storage was provided for sand, broken stone, cement and coal, a system of storing bins, measuring cars, charging cars, concrete tower and distributing railroad with cable traction, which are operated very economically and successfully, and has enabled the contractor to set 250 yd. of concrete in one 8-hr. day.

The contractor for sections 3 and 4 established a floating concrete plant with a 40-ft. mixing tower, to the top of which materials are delivered by two 65-ft. derrick booms from floats adjacent to it. The materials are handled through the tower by gravity and the 2½-yd. batches of concrete delivered from the mixing machine to steel buckets loaded by derricks on trains on an elevated trestle which distribute it to the different points of the work. These sections required about 250,000 yd. of back fill, the material for which is received direct by carts from excavations made for building operations in the vicinity, and by scows and delivered from them to dump cars on the surface track by means

of an inclined belt conveyor with a capacity of 200 cu. yd. per hour. Sections 2, 3 and 4 are equipped with a number of guyed derricks with booms from 65 to 80 ft. long and from 5 to 15-tons capacity, which were occasionally moved forward to handle the heavy stone as the wall construction progressed; all of them are operated by hoisting engines provided with steam from central power plants. The 1:3:5 concrete for the walls and footings is made with Lehigh and Giant Portland cement and stone broken to pass 1½-in. ring, and is mixed very wet.

The front wall between 140th and 143rd St., is about 65 ft. high and 32 ft. thick at the base. The face is battered 1:12 and the back is offset with 18-in. footings 4 ft. high. The wall is panelled with vertical pilasters or buttresses about 8 ft. wide and 60 ft. apart. It has also a projecting course or water table about 6 ft. above grade, and the top of the wall is finished with a heavy simple moulding, coping and parapet with occasional balconies projecting about 6 ft. and supported on carved granite brackets. All of this work has a six-cut finish which contrasts effectively with the rock faced ashlar and gives an unusually artistic and attractive appearance to the massive wall. The balustrade and the upper parts of the balconies adjacent to the sidewalks have eight-cut finish. The balcony brackets are single granite stones from the Crotch Island quarry, owned by the contractors, and are about 10 ft. long, 4 ft. deep and 2½ ft. wide; their great length giving them stability in the wall where it was at first thought it would be necessary to anchor them to vertical reaction rods on account of the comparatively small weight of masonry over their end extremities. The appearance of the wall will be still farther improved by the addition of handsome granite and bronze lamp-posts.

The roadway and sidewalks at 145th St. cross under the viaduct at a slope of 12 per cent. down towards the river. This makes the descent between the east and west retaining walls so great that although there is little headway on the shore side, there is ample height on the river side. In consequence the opening is spanned at the east end by an elliptical arch with a span of 50 ft. and a rise of 10 ft. and at the west end with a full-center arch of 25 ft. radius. Both arches have cut-stone voussoirs in the face walls, beyond which they are of 1:2:4 concrete made with 1¼-in. broken stone. A vertical rib, about 6 ft. deep on the longitudinal center line of the driveway, extends across the opening and separates the elliptical from the semi-circular arch soffit. The lower edge of this rib or diaphragm terminates at the intrados of the elliptical arch. A view of the arch and viaduct east of the east portal shows only the elliptical intrados while a view from the river although theoretically commanding both the semi-circular portal and the elliptical lower edge of the center rib only shows the former because the view is upwards into the comparatively dark interior of the passage-way so that only the semi-circular soffit is apparent.

The volume of concrete in the arch ring was so great that it was thought impracticable to set it in one day, but as it was necessary to make the work on it continuous the concrete at the skew back was built up in advance of that in the arch ring and was stepped off on both sides so as to virtually form portions of the abutment. This considerably reduced the amount of concrete between verticals at the springing lines so that the remainder, which was considered as the arch proper, was laid in a single working day. The arch was supported on lagging carried by trussed centers designed as shown in the accompanying elevation of the river end and supported by wedges on falsework piles driven close to the side walls. The centers were heavier than are sometimes used for such work, and were made of solid timber trimmed to the arch curve and secured by bolted diagonals instead of using the thin segmental scarf boards often seen. The wedges were loosened and centers struck six days after the completion of the arch ring, but no settlement was ever perceptible there or on any other portions of the work so far completed.

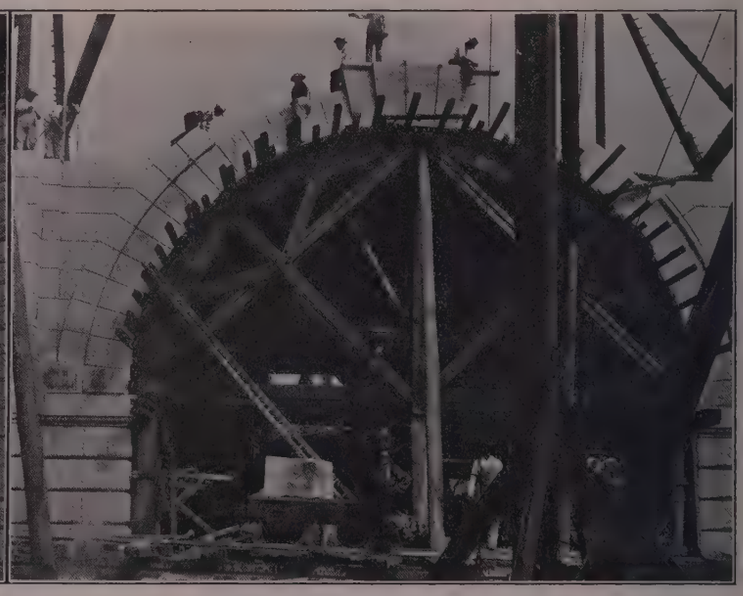
The lagging did not extend continuously through the full length of the arch. Where the ends of successive sections of lagging met in butt joints at the lines of separation between longitudinal sections of the arch rings successively built, it was found impossible to maintain the surfaces of the lagging in exactly the same plane. The result being that a slight longitudinal dislocation was formed in the concrete making an unsightly seam which was noticeable after the removal of the centers. To eliminate this, a definite joint has been provided there by cutting a small triangular groove in the concrete and the same effect will be secured in the 155th St. arch by placing a strip of triangular moulding on top of the lagging between the adjacent sections of the arch. The arch rings are reinforced with sheets of expanded metal located about one-third the distance from the intrados with the extrados, the latter being covered with felt and asphalt waterproofing and leveled up with stone and earth to the subgrade of the roadway.

Where 138th St. passes through the viaduct the headway is limited and the opening is spanned by an elliptical arch 50 ft. long with a 12½-ft. rise. The springing line is 9 ft. above the roadway crown and the arch is 28 in. thick at the crown. The abutment piers have a thickness of 11½ ft. at the springing line and are continuous with the concrete footings 17½ ft. wide. The arch will be constructed on the centering shown by the accompanying photograph which consists of heavy full length triangular trusses with braces from the panel points of the top chord to the scarf boards on which the lagging is laid. A cross section of this arch and of the maximum height of the wall was published in a general description of Riverside Drive in The Engineering Record of Feb. 11, 1905.

Opposite Trinity Cemetery in section 4, it was impossible to secure enough land to continue the regular construction of the drive. A strip only 50 ft. wide was available for a length of 700 ft., and in order to maintain the minimum width of the drives and walks, they are carried at this point on a steel platform supported by the east and west retaining walls and projecting beyond the latter so as to overhang the tracks of the New York Central & Hudson River Railroad, at a height of about 60 ft. The platform, as described in The Engineering Record of Jan. 28, 1905, has a continuous 8-in. concrete floor slab supported by 20-in. longitudinal I-beams and transverse plate girders 20 ft. apart. The latter are about 100 ft. long and 10 ft. deep with ¾-in. webs and 6x8x1-in. reinforced flange angles. They are supported near their center points by pin-connected shoes on the top of the river wall and at the shore end are seated on the other retaining wall and anchored to it by pairs of long 1⅞-in. bars engaging reaction beams built into the foot of the retaining wall. The opposite ends cantilever maximum distances of nearly 50 ft. between the center of the river wall.

Each of the long girders weighs about 60 tons and is delivered separately by three flat cars on the railroad tracks below the roadway and is unloaded from them, hoisted over 50 ft. and erected in permanent position by an overhead traveler moving on the finished portion of the viaduct outside the retaining wall. The traveler is of simple construction, consisting of a horizontal timber platform rolling on a track of about 40 ft. gauge and carrying at each front corner a derrick. The derrick masts are braced together transversely and have stiff legs from their upper ends to the rear of the platform, which is counterbalanced by the hoisting engine, boiler and other equipment. The traveler advances to the last girder erected

Front Wall Between 140th and 143rd Sts.



50-Ft. Arch at 145th St., River Face.

and lifts the girder from the cars with tackles operated by both booms simultaneously. The girder is lifted parallel to the wall until high enough to clear its upper edge, when it is revolved 90 deg. horizontally, swinging in the tackles, and is seated on the pedestal where it nearly balances. It is necessary to hoist the girders 10 ft. above their final positions in order to pass the anchor rods through the holes in the lower flanges. This is done without difficulty and the work is so accurately built and carefully handled that in 20 minutes from the time the tackles are attached to the girder on the cars it has been hoisted and erected in permanent positon, and anchor rod and pedestal connections completed. The anchor rods project about 10 ft. above the top of the inner retaining wall and therefore have a moderate amount of spring to enable them to engage the girders. After the latter are secured the masonry is built up to receive the shore ends. The viaduct contains in all about 3,000 tons of steel and twenty-seven of the 37-ft. girders had been erected on August 13.

The driveway is accessible from the intersecting streets by several flights of cut-stone stairs. Special sewers have been provided for the drainage of the driveway and water pressure is distributed from end to end in a special 6-in. main with hydrants about 1,000 ft. apart. Near 145th St. a handsome stone chamber is provided under the driveway for a public comfort station. It has a lofty vaulted ceilng lighted from above and is equipped with sanitary plumbing. The driveway is lighted with double rows of electric lights set on the curb lines about 100 ft. apart. In many places the retaining walls are completed and construction has been commenced for the paving and sidewalks, so that although no portion of the drive is yet open for traffic, the general features of design and the methods of construction were well advanced and were inspected by a party of engineers and city officials who were the guests of the chief engineer, and examined the work at an informal reception given them by the chief engineer July 19. Much praise was elicited by the exceptionally fine appearance of the masonry and great interest was taken in the details and operation of the contractor's plant installed for mixing concrete and handling materials and laying masonry.

Mr. F. Stuart Williamson is the consulting engineer and designer. The contract for section No. 2 was awarded to the Ryan-Parker Construction Co., and that for sections 3 and 4 to Mr. John C. Rogers. The steel viaduct is being built and erected by the McClintic-Marshall Construction Co.

Lowering 500 Ft. of 36-in. Water Main.

At the intersection of Crotona Ave., and Southern Boulevard, Borough of Bronx, New York City, one of the 36-in. city water mains, under a service pressure of about 40 lb., had been left partly exposed above the surface of the ground by the grading recently done on Southern Boulevard. The profile of the pipe was a long vertical curve with a versed sine of about 2 ft. between the extremeties of the 500-ft. section. It was decided to lower the pipe to its permanent position on a uniform grade about 5 ft. in maximum depth below the original position of the pipe and as not only the domestic water supply, but also a number of large factories in the neighboring district were dependent on this main, it was essential that it should not be long out of service.

Several plans for lowering it were considered, among them the advisability of connecting the main, beyond ends of this section, with a parallel pipe at the required grade by means of curved specials, thus diverting the flow through the new line and enabling the corresponding section of the original main to be removed. It was foreseen that the time required for connecting the old and new portions of the pipe would necessitate interruption of the water supply and this together with the large amount of excavation required for the bypass which was chiefly in rock caused the rejection of this plan.

The plan finally pursued consisted of a very simple and efficient method of lowering the pipe vertically in place without disturbing the original connections and with only a very short period in which the water was cut off from the lower district. Trenches about 3 ft. wide were opened on both sides of the pipe, having a combined width of about 9 ft. from out to out. These were carried down to the surface of the rock and all the material originally backfilled over the pipe was removed, exposing the sides and bottom of the original trench. Survey was then made, the elevation recorded for purposes of estimate and the 3-ft. trenches were extended on both sides of the main to the required grade at a maximum depth of 7 ft. below the original surface. The rock underneath the pipe was then removed by working in from these trenches leaving pillars supporting the main at the hubs 12 ft. apart on which each length of pipe was supported by its original wooden bed blocks. Each length was supported at its middle point by horizontal transverse wooden blocking built up solid from the bottom of the trench. The rock pillars and bed blocks were then removed, and the bed of the trench dressed to grade and recessed to clear the hubs.

The whole pipe having thus been exposed and supported, operations were commenced at one end by a gang of about 25 men with four 10-ton jack screws and three wheel-tripod derricks fitted with hand windlasses. The jack screws were set underneath consecutive lengths of pipe on the center line, as near as possible to the wooden cribbing, and were operated until they released the latter. The upper blocks were then removed and the pipe was lowered a maximum amount of about 2 in. at the center of the five-length portion under treatment. The jacks were then operated very carefully so that this amount should be distributed between all of the six joints affected, thus reducing the movement in each joint to a uniform amount of ⅛ in. and flattening the curve originally made by the axis of the pipe. When this operation was completed, the jacks were moved forward to support the succeeding five lengths of pipe and the operations were extended over the whole 500 ft. exposed.

When the main had thus been reduced from a circular curve to a uniform grade, the operations were continued by placing the jacks at one end of the main and lowering it bodily as before in six-length portions successively from one end to the other and returning, effecting a depression of from 2 to 3 in. at each trip. By repetitions of this process the pipe was finally lowered to its required position at the new grade. When the distance between the pipe and the bottom of the trench became so small that there was no clearance for the jacks their use was discontinued and the remainder of the lowering was effected by the wheel derricks.

Trenching was commenced July 18, and was completed and the pipe supported on the timber cribs ready for depression August 25. In order to avoid interference with the manufacturing establishments the lowering of the pipe was postponed until Sunday, August 26, when the water was shut off at 6 in the morning, and the jacking commenced. It was completed and the pipe was under process of filling at 5 o'clock in the evening of the same day. A sleeve existed in this section of the main allowing sufficient play to provide for the excess length of pipe developed by the change from the curved to the straight line and thus enabled the new alignment to be in a straight line without lateral displacement. The work was done under the direction of the department of water supply of New York, Mr. I. M. de Varona, chief engineer, Mr. C. H. Steers, assistant engineer in charge. Mr. Lewis D. Gregory was the contractor for the work.

Erection of Cantilever Girders Over Railroad Tracks.

Camber Adjustments Made in the Erection of the Quebec Bridge.

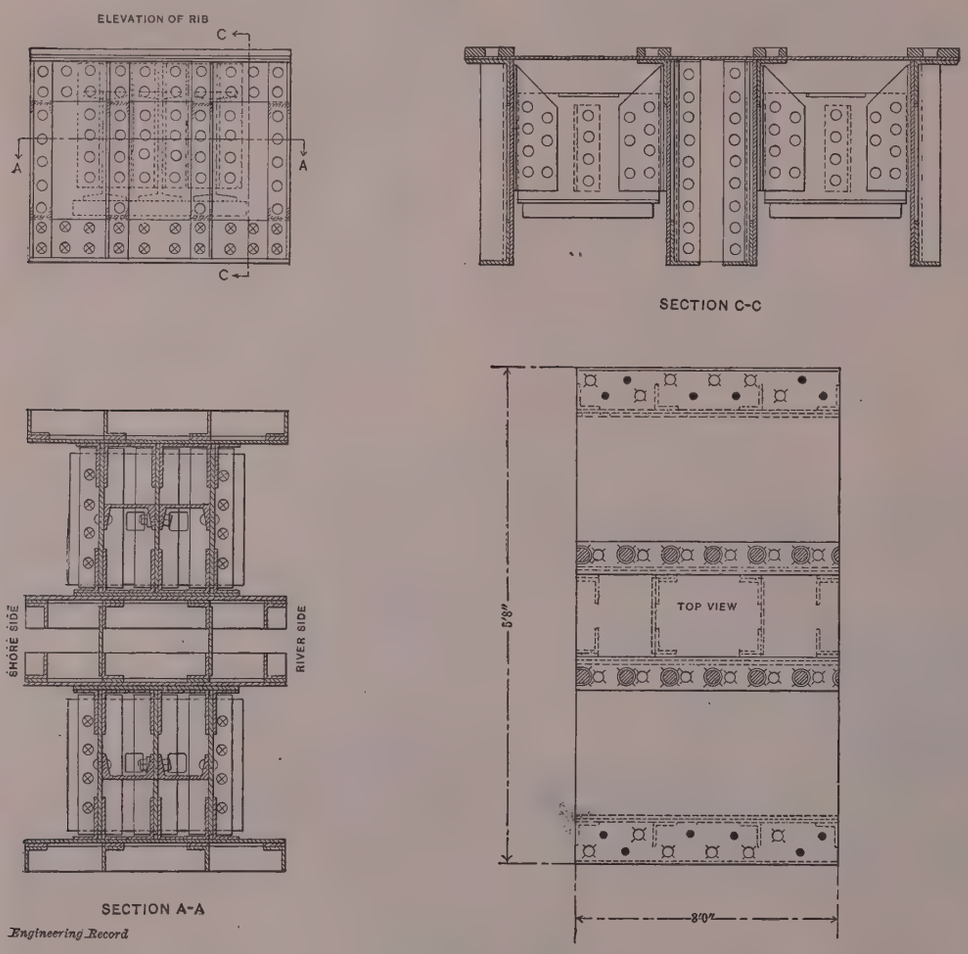
As a maximum load on a single primary tower of the Quebec Bridge is 1,000,000 lb., and it is necessary to sustain and adjust it accurately and provide for possible settlement of the falsework, and for a considerable movement due to camber, the construction above the post developed features of an important and unusual character. The arrangement there essentially consists of cellular steel platforms in an upper and lower tier, separated by powerful hydraulic jacks and taking the place of the ordinary wooden cribbing and wedges familiar to camber adjustments of moderate length spans. The horizontal distance between lower chord panel points Lo and L10 at the extremities of the anchor arm is 500 ft. 5 11/16 in. and the vertical distance is 106 ft. 3 3/16 in. for the trusses as assembled before the erection of the cantilever arm is commenced. From Lo to L4 the bottom chord has an upward camber of 1 ft. 9⅝ in. From L4 to L10 the chords follow a parabolic curve and the differences in heights of the pins increase rapidly from nearly 3 ft. to over 20 ft. The camber blocks up to L5 therefore, support practically horizontal chord members and have regular horizontal upper surfaces. Beyond L4, the upper surfaces are made special and are beveled to a maximum of almost 45 deg. to correspond with the inclination of the chords, to which they are secured by as many as 46 bolts proportioned for the sliding stress on the camber block.

The I-beam grillages on the tops of the towers are provided on the upper surface with transverse guide angles at the ends, between which is secured a grillage of cross tiers of timber forming a cushion for the camber blocks, each of which is fastened to it by eight vertical posts. The camber blocks are set on the cushion as indicated in the diagrams for the general elevations and are arranged so that the chambers in the upper and lower blocks match and afford spaces for a pair of 500-ton jacks. The webs of the upper and lower blocks are in coincident planes and at the upper edge in the lower block and at the lower edge in the upper block, are provided with flanges between which there is only a slight clearance when the jacks are not extended. When the jacks are extended the spaces between these flanges are kept filled with steel shims to give immediate bearing if the jacks should fail. Longitudinal guide strips on the upper surface of the upper blocks engage the flanges of the bottom chords and keep the blocks in position.

The lower blocks are duplicates for all of the eighteen panel points supported, and virtually consist of four transverse plate girders 2 ft. deep and 4 ft. long with their bottom flanges riveted to a ½-in. base plate about 5½ ft. long and connected by two full depth transverse diaphragms in the middle of the center girders, and by six transverse 12-in. 40-lb. I-beams about 20 in. long between the outer and inner girders on each side of the center line. The I-beams are very strongly riveted to the girders and to the base plate and their upper flanges serve to receive the 500-ton hydraulic jacks. The top flanges of the transverse girders are opposite the bottom flanges of the upper camber blocks and receive steel shims packed in to follow the operation of the jacks.

The upper camber blocks vary with the inclination of the bottom chord at different panel points. The general construction is illustrated by the accompanying drawings of the block for panel points L2. It resembles the lower block reversed, but is smaller and deeper. The four transverse 2½-ft. plate girders are 3 ft. long, have their top flange riveted to a 36x⅜x68-in. cover plate with beveled filters 1¼ in. thick riveted to it over the flanges to receive the chord flanges. There are only four longitudinal I-beams on each side of the center and these are riveted to the girder webs but not to the top cover plate. Their webs are stiffened and connected by longitudinal diaphragms consisting of short vertical 7-in. channels and the bottom flanges are countersunk riveted to base plates 2⅜ in. thick which engage the upper ends of the hydraulic jacks.

Mr. A. E. Hoare is the chief engineer and Mr. Theodore Cooper, consulting engineer, of the Quebec Bridge Co. The contractor for the steel work and erection is the Phœnix Bridge Co., Mr. David Reeves, president; Mr. John Sterling Deans, chief engineer, and Mr. A. B. Milliken, superintendent, and Mr. G. A. Tretter, assistant to superintendent of erection.



Upper Camber Block.

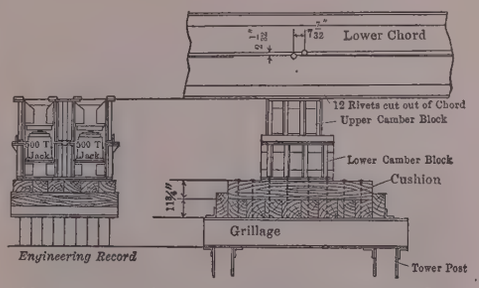
Main Traveler Erecting Anchor Arm Oct. 10, 1905.

Electric Motor-Driven Farm Machinery.

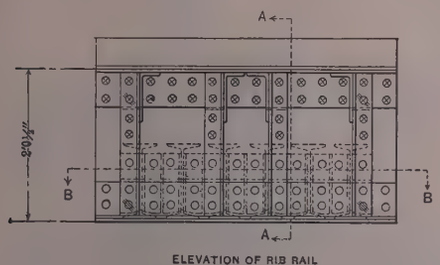
It frequently happens that the capacity of the generating station of an interurban railroad is large enough to permit the disposal of a great deal of power if purchasers could be found. Some companies have pushed the sale of power for lighting towns along the right-of-way and for operating motors in these towns, but in a very few instances have attempts been made to supply power to farmers along the line. There should be, however, quite a field for the sale of current for this purpose. Windmills are too unreliable for the average farmer and gasoline engines require time in starting and considerable maintenance. The electric motor is always ready for service, and if not abused or overloaded, there is very little likelihood of it getting out of order. Moreover, the installation of a motor does not increase the fire risk, and the cost of operation is not excessive.

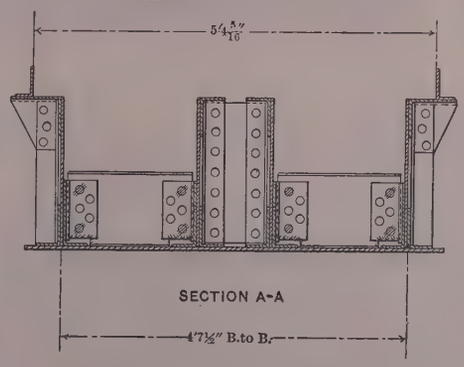
A number of motors have been installed on farms along the line of the Aurora, Elgin & Chicago Electric Ry. in Illinois. In this instance, the railway simply furnishes the power. The work of installation was done by local electrical contractors. Within five or six miles of Elgin there are about fifteen installations, and others are found scattered along the line. The district around Elgin is noted for its dairy products, and the motors are in most cases employed to drive feed-crushing and grinding machinery. In almost every instance the motor is installed in a detached building, and a chute is provided for protection to the belt, which drives the line shaft in the building in which the machinery is installed. In installing the motors every precaution has been taken to protect them from the weather, and to prevent possible damage to the wiring. The houses covering them are built water-tight, and are lined inside with sheet asbestos. A meter is installed in the house with each motor, which is usually of 15-h.-p. capacity. The total cost of installation of a motor is about $600. This includes the cost of erection of the building, the cost of the motor, the expenses of running the line from the tracks of the railway, and the work of installing the wiring and connections. The rate charged by the railway company is usually 4 cents per kilowatt. In one instance, the cost of the current used in grinding corn for 50 cows, and sawing wood, etc., was $2 per month. The cost was about one-half cent per bushel for grinding corn.

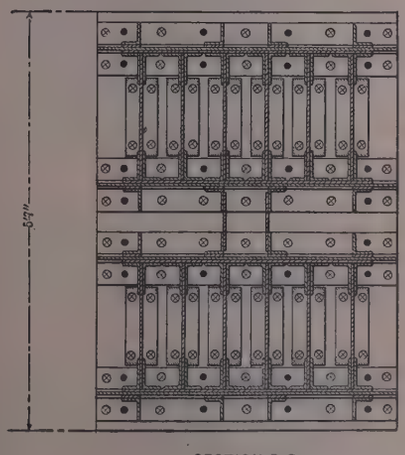
The farmers are all highly pleased with the performance of the motors, as practically no trouble has been experienced with any of them. All the care that the motors have required has been that of oiling at frequent intervals and renewal of the brushes once or twice a year. Power for the motors is taken direct from the trolley wire of the electric railway, and carried on pole lines to the motor house. The advantage to a railway company, having surplus power, of supplying such service can readily be seen, as local firms can be induced to make the installations, and then all the company is required to do is to read the meter and collect the bills.

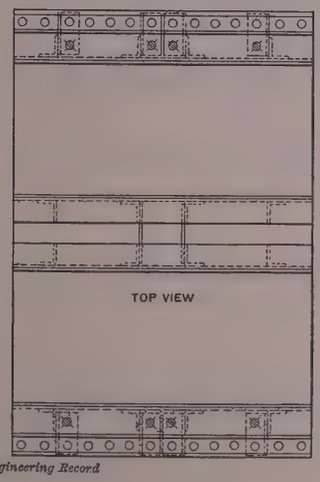


Upper and Lower Camber Blocks Assembled.









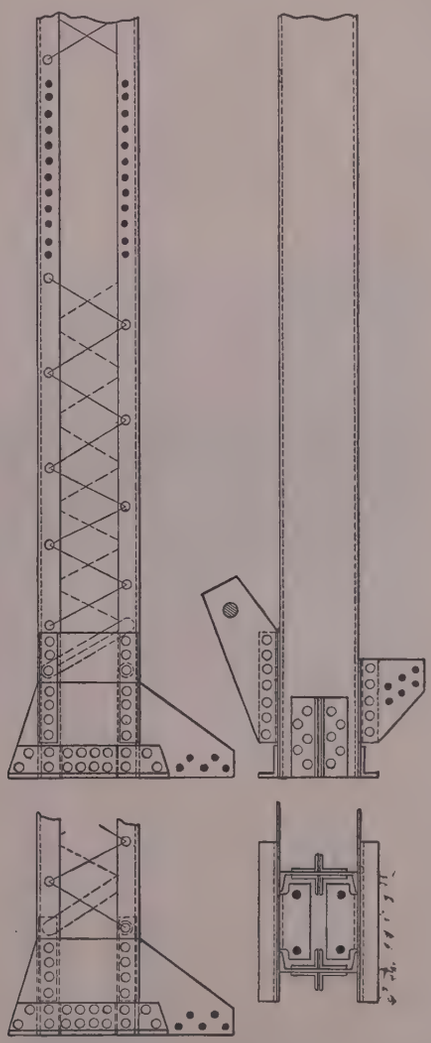
Lower Camber Block, Quebec Bridge.

Refuse Disposal by Incineration is to be used at Paris, France, and three large destructors are being installed in different parts of the city, each of a normal capacity of 100 tons of refuse per 24 hr. Each station will be fitted with three regenerative Meldrum furnaces, and large Babcock & Wilcox boilers for steam generation.

The Relocation of Public Service Systems During the Grade Raising of Galveston, Tex.

Interesting problems have attended the work of raising the grade of the city of Galveston, Texas, subsequent to the building of the concrete sea wall on the water front. The sea wall and grade-raising improvements which were undertaken to prevent the recurrence of the flood disaster which devastated the city on Sept. 8, 1900, have been referred to in detail in The Engineering Record; the construction of the sea wall which has been built to a height of 16 ft. for some 3½ miles along the open sea front of the city was described in the issue of July 4, 1903. With this undertaking was entailed the work of raising the grade of the lower portions of the city adjacent to the sea which were more particularly affected in the flood than the business section of the city toward the rear. An entirely new grade was established for the city which involved the filling in of a solid backing for the sea wall and the raising of the entire lower portion of the city between the wall and the business section from a few inches up to 16 ft., in order to prevent water from the gulf, in the most severe storms, from entering the city again. This change has necessitated practically the reconstruction of the residence portion of the city. The methods employed in this change of grade, which are being accomplished by a method of hydraulic dredging and have involved the handling of nearly 15,000,000 cu. yd. of material, were described in The Engineering Record for March 11, 1905.

One of the important features of the change of grade of the city was the necessary relocation



Upper Section of Falsework Post.

of all public services, including water and gas pipes, sewers, street railway tracks and other public service systems. The streets in the districts affected were raised in grade on an average of 8 ft., which necessitated corresponding elevation of the street railway tracks, poles, sidewalks, fences, and buildings of all kinds, and also owing to the depths to which all sewers and underground pipes would thus be buried, it was deemed necessary to raise them also to correspond to the new grades; the change of grade was particularly advantageous to the sewer system, as with the elevation, a drainage was secured which had been impossible with the former level topography of the city. Much of this relocation was, however, necessarily attended with great difficulty as the majority of the houses in the districts raised were occupied and it was accordingly necessary to maintain water and gas supply connections, and also the street car service, as fully as possible.

The area of the section of the city to be filled embraced about two square miles, which required filling to a height of 16 ft. back of the sea wall and to lesser depths farther back toward the center city as the natural grade of the island rises. The material used for fill was sand dredged from the channels of Galveston Bay, at the rear of the city, which material was handled by special hydraulic steam dredges carrying hopper pockets, by means of which it was transported and delivered into the city. The areas of the channel dredged and the section of the city filled are shown in a map published in the article in the issue for March 11, 1905. To simplify the delivery of the material to the areas to be filled, a canal, 200 ft. wide and 20 ft. deep, in which the self-propelled dredges could navigate, was dug just within the sea wall throughout the section to be filled. The canal was slightly over 3 miles in length, entering the city from Galveston Bay at the rear of the island and following closely the line of the sea wall as far as 21st St., where it deviated from the wall at an angle of about 30 deg. and continued for some 6,000 ft. further. This canal was dug by dipper dredges, the material excavated being used in levees to retain the sand delivered hydraulically along the canal. It will be filled in by the same process at the completion of the work.

About 400 city blocks were affected by the grade-raising operations and over 2,000 private dwellings had to be raised to the new grade. The larger and more substantial buildings which were in such condition as to make it more economical to raise than tear down and rebuild, were raised by the ordinary methods of house raising and new foundation walls built under them before the filling was commenced around them. Many buildings were torn down and the material removed until the work was completed. In the majority of cases, the larger buildings were raised to correspond with the new grade and supported there by substantial brick piers which should serve for the foundation walls at the new grade. The smaller buildings were supported on posts carefully braced laterally to prevent the inrush of the water and sand from undermining them. This procedure was also resorted to in the relocation of fences, sidewalks, flower beds and other structures too bulky to move. Sidewalks were in this way maintained in many sections throughout the grade-raising operations. For the supply of water and gas to the houses while being raised, effective temporary connections were made by hose until the street mains were also raised and new service connections could be made.

The construction of the canal cut off all street car lines and gas or water piping which had extended near the sea wall. The street railway system was particularly affected in this manner as it had a number of north and south lines to different points on the beach that were heavily patronized by excursionists. Five lines of the railway company, the Galveston Electric Co., were thus interrupted and the usual connections to the beach entirely cut off. Temporary tracks were laid where possible to extend around and beyond the canal to the beach, but these and the other lines near the canal were, of course, subjected to continual relocation during the progress of the grade-raising operations.

Gas Pipe Raised before Filling.

The railway company undertook to accommodate its lines to the raising of the grade, by raising its tracks a few inches at a time as the filling proceeded, maintaining its service only on such lines as were most needed. Considerable difficulty was experienced in devising a method of raising the tracks which should bring them to the future grade and permit filling in under the ties. The methods resorted to in raising the dwellings and other buildings was possible only on certain lines of track which could be temporarily abandoned. For such lines as were used during grade raising operations, it was found impossible to so support the track, that it would be safe for cars to operate over, owing to the method of filling employed. As the dredges, when unloading material on the area to be filled, forced the water and sand mixture out of the large delivery pipes at a pressure of 18 to 20 lb., and as the mixture averaged 75 per cent. of sea water and only about 25 per cent. of sand, the washing effect was enormous. A track that had been erected on the timber cribbing would have been quickly washed out and undermined by the force of the water delivering the sand in the filling process, thus rendering it unsafe for travel.

Accordingly decision was made to follow the grade raising operations by allowing the sand delivered from the dredges to fill in around and over the track until nearly or entirely above the rails, and then to jack the track up a few inches at a time. This process was followed throughout the work for all lines under operation and found successful. It frequently necessitated rapid work while the filling operation was in progress in order to keep the track above the sand, and great difficulties were experienced, owing to the softness of the wet sand as it settled. Frequently the jacks even when mounted on blocking would sink 6 in. before they could raise the track 1 in. and rapid shoveling was always necessary to ballast the track up before it would sink again. Furthermore, as the filling was dependent on a direction of inflow from the dredge delivery pipes and this direction of flow was changing frequently, as the sand filled and obstructed itself, the track raising was neither a continuous nor a uniform operation; in many places the track would be raised much higher than others and often a change of flow without warning, would submerge low portions, so that quick work was required to raise the track before being deeply covered.

During all of the grade raising the cars were operated with commendable regularity although under great difficulties. Often considerable sections through which it was necessary to operate the cars in order to maintain the service would become entirely submerged. In such cases sound was the only guide by which the motorman could determine his way over the unseen track. As the streets were for the greater part of the time covered with water, regular stops were abandoned and the conductors in long rubber boots assisted passengers to and from sidewalks, or their homes. At times during the filling operations, when a dredge was pumping clean water in starting the delivery of sand or before stopping in order to clean the sand out of the delivery pipe, the tracks often became badly washed out and undermined. In other cases sections of track which became submerged and finally covered with sand to a considerable depth before the raising gang could follow it up to jack the track above the surface, were put entirely out of commission. Especially was this condition encountered at night and in bad weather as the dredges were operated day and night, every day in the week and in bad weather as well as good. In such a case the track could not be successfully raised until the dredge had ceased to operate so that the sand might be dug off the track, oftentimes a depth of several feet, and the track subsequently jacked up and hastily surfaced on an underfilling of the wet sand.

Accompanying the laborious process of raising the track, were difficulties of a serious order in maintaining the overhead wiring equipment of the railway lines in operating condition and clear of cars and pedestrians on the streets. As the sand was filled in around the poles 6 to 8-ft. extensions of 2x4-in. scantling were nailed to the poles so as to support the live trolley wires at higher levels, a large amount of temporary work

One of the Self-Propelled Hopper Dredges used for Grade Raising at Galveston.

having been thus installed, until at completion of the work, the original poles were 12 to 18 ft. in the ground. Further difficulties were encountered in the location of guy and brace poles owing to the unstable condition of the sand. Corner poles and those having a heavy strain on them in any particular direction are guyed and braced with particular care at Galveston, and accordingly every time a pole was raised a few inches, one guy had to be slackened, another tightened to equalize the strain and prevent the pole being pulled entirely out of the ground.

In bringing the overhead lines up to the new grade at the completion of the work, it was, owing to the condition of the soil, found impossible to raise the original poles by excavating around them until after the newly filled soil had been given two or three months to settle. A very simple method of raising the poles, was, however, finally determined after much experimentation with stump pullers and other hoisting apparatus. This method involved two 30-ft. levers strongly braced with steel which were used with a fulcrum of blocking and planking of 3x12-in. plank. The blocking was spread around the pole to form a firm foundation for the fulcrum, over which the levers were located and attached to the base of the pole by a log chain grip. Then, with the weight of 10 or 12 men bearing down on the raised end of the big levers, the pole was usually started. Owing to the plank and fulcrum sinking, usually several inches into the soft sand, however, it was rarely possible to lift the pole more than an inch or two on the first lift. The chain grip would then be adjusted a second time, when it was ordinarily possible to raise the pole about 3 in., while the third time it came up 4 in. or more and afterwards about 6 in. at a lift. All the poles were raised to the same relative position which they occupied before the work of changing the grade began, while the guys and bracing were attended to with special care.

In elevating the gas and water mains during the grade-raising operations, three methods were considered, first to raise the pipes after the change of grade had been completed, laying new mains where the old ones could not be profitably raised; second, to take up the mains in the sections to be filled and afterwards re-lay them to conform to the new grade when completed; and third, to raise the mains before the grade was raised. The gas company objected to the first method on account of its great cost of raising and the risk of breakage, especially with the smaller sized mains. The city water department at first, adopted this plan, but after extensive trial found it unsuccessful and abandoned it. The second method was adopted on a number of streets where the service would not be crippled by the abandonment of the mains, while the third method was utilized by the gas company from the start and later by the water department. With this method only temporary interruptions occurred from the breaking of mains and laying of new surface connections.

The city water department, after first attempting to excavate and raise the pipes after the filling had been placed and settled, and finding, after a number of weeks of hard work that practically nothing was being accomplished, abandoned this method and advertised for bids to handle the work in that manner. The bids were all rejected, however, for the reason that the prices demanded by contractors would have bankrupted the city.

Discharge of Sand and Water from a 42-in. Delivery Pipe.

Houses and Tracks Raised for Filling.

Typical Method of Delivering Sand with Water.

Owing to the success which the gas company was experiencing in raising its mains in advance of the grade raising operations the water department finally adopted the same policy which has been found successful throughout. The procedure followed was, in general, to excavate down to the mains and the service connections, after which the mains and all were lifted progressively a little at a time by chain blocks on tripod derricks, and the trenches filled in under them, so as to avoid breaking joints and interrupting service. When the mains were finally brought up above ground level, to a point where they could no longer be supported on the soil, they were carried on temporary supports and when up to their new grade, on firm struts nailed to timbers driven into the ground on either side of the main. When thus supported, the action of the water and sand when pumped in for the filling process could not undermine the main or in any way disturb it.

The method used in raising the gas mains was very similar, the scheme of raising them in advance of the grade-raising operations, proving very successful. The experiences and difficulties encountered by the gas company in making the changes of grade, and of accommodating the work to that of the grade-raising operations, were described in a paper presented before the Western Gas Association by Mr. John Gimper, general manager of the Galveston Gas Co., an abstract of which paper follows:

The changes in grade, where the gas mains were lying, are from 3 to 8 ft. and the sizes of mains involved are 3, 4, 6 and 8 in. The majority of these were laid many years ago, since when the tendency has constantly been to raise the grade of the streets in order to obtain better drainage. For this reason the gradual filling in on all streets have placed the old mains from 4 to 5 ft. below the surface and they were in practically all places in water.

In raising the mains, the first method, of raising after the change of grade had been completed, was rejected on account of the increased cost and the greater risk of breakage, especially with the smaller sized mains. The second method, of taking up all mains in the sections to be filled and re-laying them to conform to the new grade, was also rejected on account of the loss of business, as the time intervening between taking up the mains and relaying them would be too long. The third method, of elevating the mains before the grade was raised, was therefore adopted and the supply of gas maintained throughout during the changes to mains and services. Only temporary interruptions occurred, owing to the breaking of mains and to the laying of new services, as all the street mains had fortunately been laid with lead joints.

The dredging contractors were allowed to fill 16 blocks at one time, and they had the privilege of taking the earth from any street in the section to be filled for constructing dams and ditches to confine the sand and return the water to the canal. Many unforeseen difficulties arose from this procedure. In several blocks they took all the earth from the gas mains and services. Two lines of mains came within their drainage ditches so that the mains had to be supported by 4x4-in. timbers and cross pieces spiked to them. At times the dams were not high enough or too weak, and the water would overflow or break through into the section where a main was being excavated. This would generally happen during the night and the result, of course, was very annoying.

In the early days of Galveston many bayous existed, which were in time filled and streets laid through them, and eventually gas mains were laid in those streets. To make excavations in those localities is very troublesome to this day, and especially after rains. Cave-ins occur in good localities, but are the regular rule in these old bayous. As soon as a main was raised from its watery bed, sometimes only the height of its diameter, the void thus created would immediately be filled by the soft sandy sides slipping down, a crack

would form on top, and before it could be prevented the bank would fall on the suspended pipe, it would be buried again, and if it happened to be a 3-in. pipe it would sometimes break.

The contractors always prepared the section of 16 blocks adjoining the one they were filling a month before they pumped into it, which meant the construction of dams and levees, and the destruction of all surface drainage in that section, so that after rains the water had no way of escape. It was therefore not desirable to do any ditching in that section, hence work was always pushed into the second section ahead. In doing so, however, the difficulty of protecting service pipes from wheel travel was encountered until the section would be closed. It seemed that every delivery wagon, dray or other vehicle would always drive, not where a good crossing was provided for them, but where they could do the most harm. Sometimes within a month, services having been bent and trapped, would have to be relaid, as it was of the utmost importance to have no breaks or leaks, and it would be utterly impossible to find them when pumping had begun.

Since not only streets and alleys, but lots also, were raised to grade, the houses likewise had to be raised. To keep up the supply of gas during the house raising, the service riser was cut and a piece of garden hose connected with it until the house was up to the proper height, when permanent connection was restored. The house raiser and brick mason often gave trouble by setting cribbing and jackscrews or a brick pier over service pipes. The city authorities thought it prudent to lay as many sewers as possible before the grade raising, and, as a matter of course, they would find the gas mains in their way. The orders to move the main came very promptly, and often at a time when men and tools could be spared the least. When the city water department concluded to adopt the method of raising their water mains ahead of the grade raising, they decided to lay their mains on top of the streets, which necessitated cutting gas pipes wherever they were crossed.

The raising of the mains was accomplished with chain blocks and derricks after stripping mains and services in open trench. No special engineering features were called for, but care had to be exercised not to place derricks too far apart. Raising was done simultaneously with all the blocks when all services had previously been cut. Filling followed at once under the main, and when raised high enough, two solid beds were tamped under each length of pipe, and a piece of yellow pine 2x8x18 or 20 in. long was tamped to true grade; all the joints were then cleaned and calked over.

It was predicted that when the water would reach this new made ditch, traps would be the result, and some misgivings were entertained about the final outcome, but only in two instances did any traps occur. One case was where a large discharge pipe delivered water directly against 3-in. pipe line and no doubt undermined it. A later method of discharging through an upturned elbow was adopted with which there is no wash or undermining. The second instance was where only one piece of yellow pine was used instead of two under each pipe. The large flood of water spreading over a pipe line uniformly was, no doubt, a safety factor in settling everything uniformly.

On one street a double line of mains exist, and during the filling of the adjacent territory no leaks at all occurred in the mains. After that part of the territory was filled and the work extended further north, however, the contractors laid a 40-in. discharge main directly over a gas main that had been raised. This gas main was laid with cement joints, and stood on 4x4-in. timbers. After they had been pumping a little while a leak occurred which showed itself at one of the gas pumping stations near by there, and the leak increased from day to day. Of course it was impossible to do anything to find the leak during the filling process, all the ground around the main being quicksand, so it was necessary to keep a man pumping. This pumping was continued day and night for three weeks, so as to keep the line open.

About three months after the first three sections of the filling had been completed and the necessity for the extension of a block of mains had arisen, an attempt to find the end of the main was made, but failed utterly because of the water encountered 20 in. below the surface. Five months later the men succeeded in making the extension. This was at a point where only a 3-ft. fill was made. These conditions do not obtain everywhere, for when two months after the filling had been completed at another point one block from the canal, a new service pipe was laid where the main was 7 ft. 4 in. deep, and better conditions were found than in the places to which reference has just been made, due no doubt to the closer proximity to the canal, which facilitates drainage. But two blocks away it was five months before an extension to the mains could be made. There is a great difference in the kind of material the dredges pick up in the channel; sometimes it is purely quicksand, and again it is coarse sand and fine shells.

The raising and relaying of the mains and services has not altogether been a loss to the gas company. Connections have been found of which there was no record. Old leaky service pipes lost for 20 years, furnish no longer water into the mains or loose gas. The number of pumping stations have been reduced. Eighty-four blocks, three street intersections and over 400 service connections have been gone over during 1905. At this date there still remains the southwestern part of the street main system to be raised.

In reply to a question as to the condition in which the mains and service connections were found, Mr. Gimper stated that some of the 3 and 4-in. mains were in very poor condition. The iron had suffered, which caused many breaks. Where the pipe was very poor it was cut out and new pipe put in. It was due, he thought, very much to the quality of the iron when the pipe was put in many years ago. But as far as the service pipes were concerned trouble from salt water has been experienced always, so that it is necessary to replace them often, because they practically lie in salt water. The raising of the grade is now nothing else but salt water and sand. It has been the practice in Galveston for years, 16 years and over, to use only extra strong pipe, and only strictly soft wrought-iron pipe. Steel pipe is not used. For fittings it is necessary to use brass; all elbows and fittings that are lying in the ground are brass. There are fittings that have been in 20 years, and they can be taken up and put right back again.

The grade raising operations, to which detailed reference was made in this journal, March 11, 1905, were carried out by Goedhart & Bates, New York. The system of hydraulic dredging used, is the invention of Mr. Lindon W. Bates, of this company.

Lowering a Four-Track Railroad in a Rock Cut.

An interesting grade-lowering operation has recently been carried out by the New York, New Haven & Hartford R. R. on its four-track line through Mount Vernon, N. Y., to provide greater overhead clearances for its new electrical equipment, now being installed between Woodlawn, N. Y., and Stamford, Conn. A minimum clearance of 17 ft. was decided on for this section of the system and as in Mount Vernon there were a number of bridges clearing the tracks by only from 14 ft. 8 in. to 15¼ ft., it was necessary to either raise these bridges or lower the tracks from 1½ ft. to 2 ft. 4 in. The former was, of course, the more desirable, but owing to the disturbances of grades of the streets in Mount Vernon that would result, it was impracticable. It was accordingly decided to lower the tracks which could be done quickly, and, owing to the four tracks, with little delay to traffic.

The line passes through Mount Vernon for the greater part in a thorough cut in rock, with high retaining walls on either side, which is spanned at four places by bridges, three at Third, Fourth and Sixth Aves., near the passenger depot, while the fourth is at South St., one-half mile to the west. The passenger station is located in a depressed area at the east of the cut into which the latter widens, with a retaining wall at the south side only. The work necessitated lowering the station platforms and sheds, and also it was necessary to provide against interruptions of both local and through traffic at all times. The latter was accomplished by turning traffic on two of the four tracks temporarily, while a third was used for a work track for the lowering operations on the fourth.

Water to be Drained off after Partial Filling of a District.

The tracks were all previously rock ballasted, which necessitated first the removal of the ballast, before the excavation of the bed could be begun. Then, as the maximum depth of excavation was only about two feet, the drill holes were located on 2-ft. centers and a channeling machine was run along the face of the retaining walls. Some protection was found necessary for the foundations of the retaining walls against frost, which was accomplished by underpinning with concrete. Even where the walls rested on rock it was found necessary to remove more or less rotten rock under them and replace it with concrete, which was faced a little way up the side.

At the passenger station about 2,500 sq. yd. of granolithic platform were torn out and rebuilt to meet the new grade, and also 100 ft. of both the east and west-bound platform cover sheds had to be lowered. As in freshet time, water has in the past been more or less troublesome to the tracks, so with a depression of 2 ft. more some drainage system had to be provided; accordingly a 2-ft. overflow sewer was built for 1,000 ft. to take care of unusually heavy flows. The contract was carried out by Lathrop & Shea, under the supervision of Mr. F. H. Ellsworth, division engineer, of New Haven, Conn.

The Value of Pure Water—II.

By George C. Whipple. One of several papers prepared in commemoration of the twenty-fifth anniversary of the doctorate of Prof. William T. Sedgwick.

Hardness.—The point at which a water becomes objectionably hard has never been exactly defined. Standards of hardness vary in different parts of the country. The ordinary person washing his hands considers the water soft if the soap will quickly produce a suds without curdling. A hardness of 10 parts per million is practically unnoticeable, and it requires a hardness of 20 to 30 parts per million to produce curdling. Waters which have a hardness below 25 parts per million seldom cause much complaint, but when the hardness rises above 50 the water is well entitled to the appellation hard, and above 100 it may be called very hard. In some parts of the country hardnesses of 200 or 300 are observed; these may be termed excessive.

In 1903 a number of experiments were made by the writer to determine the effect of various degrees of hardness on the amount of soap produced in washing the hands, in bathing, and in general household uses. These showed that the hardness of the water had a substantial effect on the use of soap. Tests were made with eight of the common soaps and washing powders on the market, to determine how much of the average soap used in a household it would take to completely soften waters of different degrees of hardness. Comparative figures were also obtained for the standard castile soap commonly used in the laboratory making the soap test for hardness. The results of these experiments are given in Table V.

It was found that one pound of the average soap would soften 167 gal. of water which had a hardness of 20 parts per million. This was equivalent to about three tons of soap per million gallons, which, at a cost of five cents per pound, would amount to $300 per million gallons. It was also found that for every increase of one part per million of hardness the cost of soap increased about $10 per million gallons of water completely softened. The following table shows the way in which this amount was calculated:

TABLE VI.

Table Showing the Average Cost of Softening Water by Soap.

Hardness (parts per million).	Avg. No. of gals. of water softened by one lb. of average soap.	Avg. No. of lbs. of soap required to soften 1 million gals. of water.	Increase in hardness above 20 parts per million.	Increase in No. of lbs. of soap required to soften 1 million gals. of water.	Increase in No. of lbs. of soap required to soften 1 million gals. of water for each part per million increase in hardness.	Increase in cost of soap per million gals. for each part per million of hardness at 5c. per lbs.
20	167	5,990				
25	147	6,810	5	820	164	$8.20
40	97	10,300	20	4,310	215	10.75
50	82	12,200	30	6,210	207	10.35
75	57	17,500	55	11,510	209	10.45
60	54	18,500	60	12,510	209	10.45
100	45	22,200	80	16,210	203	10.15
125	37	27,100	105	21,110	200	10.00
150	31	32,200	130	26,210	202	10.10
175	27	37,100	155	31,110	201	10.05
200	24	41,700	180	35,710	129	9.95
				Average.....	201	$10.05

All of the water used by a community is not completely softened. The number of gallons per capita per day completely softened has been estimated by different authorities all the way from 1 to 10. It will certainly be a conservative estimate to assume that one gallon per capita is thus softened, or 1 per cent. of the total consumption of this is assumed to be 100 gal. per capita. On this basis the depreciation value of water, on account of its hardness, is

$$D = \frac{H \times 10}{100} = \frac{H}{10}$$, in which H equals the hardness of the water in parts per million, and D the depreciative value in dollars per million gallons.

Example: Assume the total hardness of a water to be 79 parts per million; then $D = \frac{79}{10} = \$7.90$ per million gallons.

This takes into account only the cost of soap used for domestic purposes, and does not include the incidental losses and inconveniences attendant upon the use of hard water in the household. These, if they could be expressed in terms of dollars and cents, would probably more than equal the cost of soap; therefore the above figures err on the side of conservatism.

TABLE V.

Table Showing the Relation Between the Hardness of Water and the Amount of Soap Required to Soften It.

Hardness (parts per million).	No. of cc. of standard soap solution for 50 cc. water.	No. of grams of standard soap per gal. of water.	Number of Gallons of Water Softened by One Pound of— Standard Castile soap.	Ivory soap.	Babbitts laundry soap.	Sapolio.	Bon Ami.	Gold Dust.	Pearline.	Pear's hand soap.	Colgate's Cerosa Toilet Soap.	Avg. (omitting the standard Castile Soap).
20	2.1	1.11	409	196	138	102	143	165	167	187	225	167
25	2.4	1.27	358	174	121	90	125	145	147	164	206	147
40	3.6	1.91	238	115	80	59	83	96	98	109	137	97
50	4.3	2.28	200	96	67	50	70	81	82	92	115	82
75	6.1	3.24	140	67	47	35	49	57	58	64	80	57
80	6.4	3.49	130	70	44	33	45	52	53	60	75	54
100	7.8	4.13	110	53	37	27	38	44	45	50	63	45
125	9.5	5.04	90	43	30	25	31	36	37	41	52	37
150	11.1	5.89	77	37	26	19	27	31	32	35	44	31
175	12.7	6.74	67	32	23	17	23	27	26	31	38	27
200	14.3	7.59	60	29	20	15	21	24	25	27	34	24

Temperature.—Everyone knows that warm water is unpalatable. When the temperature rises above 60° Fahr., people do not like to drink it without cooling. The relation between the temperature of the water and the per cent. of objecting consumers may be represented by a curve based on the equation $p = \frac{(d-45)^2}{9}$, in which p equals the percentage of objecting consumers, and d equals the temperature of the water in Fahrenheit degrees. According to this curve, no one would object to drink a water which had a temperature of 45°, half the people would object at 66°, and all would object at 75°. If it is assumed that it takes one-half pound of ice per capita daily to cool the water used for drinking during four months in the year, and that ice costs 30 cents per 100 pounds, then the depreciation value due to temperature would be equivalent to $5 per million gallons of public supply for 100 per cent. of objecting consumers, assuming the per capita consumption to be 100 gal. daily, or $D = \frac{p}{100} \times \$5 = \frac{(d-45)^2}{180}$ in dollars per million gallons, in which d = the average temperature during the four warmest months of the year. This may be considered as the depreciation value due to temperature. The temperature of ground waters seldom rises above 60° Fahr. in the house taps even in summer, and in cities supplied with ground water a large proportion of the consumers do not use ice. Surface waters, on the other hand, in the latitude of New York, generally maintain a temperature of 60° Fahr., or more at the house taps for at least four months of the year. The temperature factor is an important one in many cases, but it need not be used except when comparing surface waters with ground waters.

In a similar way it might be possible to calculate the reduced value of a water due to other objectionable characteristics, such as the presence of large amounts of iron or chlorine. Except in special cases, these would not be as important as the more obvious qualities above described, and they need not be considered in this discussion.

Summary of Principal Formulas.—Depreciation due to sanitary quality—1. $D = 2.75\ (T - N)$. Depreciation due to physical characteristics—2. $D = 20\frac{p_o + p_t + p_o}{100}$ $p_o = \frac{c}{2}$; $p_t = 5\sqrt{t}$; $p_o = 2\,O^2_v + 3.5\,O^2_d = 5\,O^2$. Depreciation due to hardness—3. $D = \frac{H}{10}$. Depreciation due to temperature—

4. $D = \frac{(d-45)^2}{180}$, in which—

D = the depreciation value in dollars per million gallons;
T = typhoid fever death-rate per 100,000;
N = typhoid fever death-rate assumed to be due to causes other than water, and which may be ordinarily taken as 20 per 100,000;
p_c = percentage of consumers who object to the color of the water;
p_t = percentage of consumers who object to the turbidity of the water;
p_o = percentage of consumers who object to the odor of the water;
c = color reading;
t = turbidity reading;
O_v = odors due to vegetable matter, expressed according to standard numerical scale;
O_d = odors due to decomposition, expressed according to standard numerical scale;
O_o = odors due to microscopic organisms, expressed according to standard numerical scale;
H = hardness of water in parts per million;
d = average temperature of water during four warmest months.

Application of the Formulas.—It now remains to apply the principles above set forth to actual cases and see to what conclusions they lead.

Effect of Contamination.—The average death-rate from typhoid fever in American cities which have more than 30,000 inhabitants is about 35 per 100,000. Applying formula (1), and assuming a value of 20 for N, then $D = 2.75\ (35 - 20) = \$41.25$; that is, the average depreciation value of the water supplies of our American cities, taken as a whole, is $41.25 per million gallons because of their unsanitary quality, or about $15,000 per annum for each million gallons a day of supply.

The above figure takes into account both good and bad supplies. The average typhoid fever death-rate in those cities which have reasonably good water supplies may be taken in round numbers as about 20, while in those cities which have supplies more or less contaminated it varies from this up to 40 or 60. In some of the worst cases it is more than 100 per 100,000. In Pittsburg, for example, the typhoid death-rate for several years has averaged 120. Here, according to formula (1), $D = 2.75\ (120 - 20) = \$275$ per million gallons. This is figured, however, on a per capita water consumption of 100 gallons a day. The actual consumption is about 250 gallons per capita per day; hence D should be taken as 100/250 of $275, or $110 per million gallons. Each million gallons of polluted Allegheny River water pumped to Pittsburg has therefore reduced the vital assets of the community by $110. This, for a population of 350,000, amounts to $3,850,000 per year—

a sum enormously greater than the cost of making the water pure.

Classifying water supplies according to their source, the results of Table VI will give a general idea as to the depreciation value of various types of water from the sanitary standpoint, based on general average typhoid fever death-rates.

Effect of Turbidity, Color, and Odor.—It has been shown that the esthetic deficiency of water depends upon three variable characteristics, which may have many different combinations; consequently, it is difficult to classify the water supplies of the country on this basis. For this reason the few typical examples given in Table VIII may be more instructive than any attempt at a general classification.

It will be seen from the figures in this table that, while the general attractiveness of a water is of less importance than its sanitary quality, yet it is by no means insignificant. For instance, such a water as that now supplied to New York City from the Croton River has a depreciation value of $11 per million gallons, or nearly a million and a half dollars a year for a daily supply of 350 million gallons. At 4 per cent. this represents the interest on about $35,000,000, a sum several times as large as the cost of filtration. An algæ-laden water like that of Ludlow Reservoir at Springfield, Mass., has a depreciation value of more than $20 per million gallons, because of its odor and turbidity. A colored water like that of the Black River at Watertown before filtration has a depreciation value of $11, while a turbid water like that of the Mississippi River at St. Louis gives $25.

In most surface waters the physical characteristics vary greatly at different times of the year. During the spring and fall, for instance, the color and turbidities may be high on account of rains, while during the summer the water may have bad odors due to microscopic organisms. The depreciation value of a certain reservoir water, calculated as above described, serves well to show this seasonal variation, as illustrated by the following figures:

Effect of Hardness.—The waters of New England are comparatively soft, although in some instances the ground waters are hard. In the Middle West, on the contrary, most of the surface waters are quite hard, and in some cases the hardness is excessive. The figures in Table X serve to give an idea of the range in the depreciation value of waters due to hardness.

Effect of Filtration.—Sanitary Quality—The following figures show to what extent the sanitary value of a polluted public water supply is increased by an efficient system of filtration:

Lawrence, Mass.—

Water supply, Merrimack River, filtered by a slow sand filter.

Population, 70,000.

Water consumption, 40 gal. per capita daily.

Before filtration the typhoid fever death-rate was 121 per 100,000; since then it has been 26.

Before filtration $D = 2.75\ (121 - 20) \times 100/40 = \$693$.

After filtration $D = 2.75\ (26 - 20) \times 100/40 = \$41$.

Increase in sanitary value = $693 − $41 = $652 per million gallons, or $665,000 per year, or $9.50 per year per capita.

Albany, N. Y.—

Water supply, Hudson River, filtered by sand filter.

Population, 95,000.

Water consumption, 165 gal. per capita daily.

Before filtration the typhoid fever death-rate was 104 per 100,000; since then it has been 26.

Before filtration $D = 2.75\ (104 - 20) \times 100/165 = \$140$.

After filtration $D = 2.75\ (26 - 20) \times 100/165 = \$10$.

Increase in sanitary value = $140 − $10 = $130 per million gallons, or $450,000 per year, or $4.75 per capita per year.

Binghamton, N. Y.

Water supply, Susquehanna River, filtered by a mechanical filter.

Poulation, 42,000 (approximately).

Water consumption, 160 gal. per capita daily.

Typhoid fever death-rate before filtration, 49; after filtration, 11 per 100,000.

Before filtration $D = 2.75\ (49 - 11) \times 100/160 = \$65$.

After filtration $D = 2.75\ (11 - 11) \times 100/160 = 0$.

Increase in sanitary value = $65.00 per million gallons, or $160,000 per year, or $3.80 per capita per year.

Watertown, N. Y.—

Water supply, Black River, filtered by mechanical filter.

Population, 25,500 (approximately).

Water consumption, 160 gal. per capita daily.

Typhoid fever death-rate before filtration, 68 per 100,000; after filtration, 19.5.

Before filtration $D = 2.75\ (68 - 20) \times 100/160 = \$82.50$.

After filtration $D = 2.75\ (20 - 20) \times 100/10 = 0$.

Increase in sanitary value = $82.50 per million gallons, or $120,000 per year, or $4.75 per capita per year.

Illustrations like the above might be multiplied but the four cases selected are sufficient to illustrate the general fact. It is easily seen from them that the filtration of a polluted public water supply increases to a very great extent the vital assets of a community, and the increase in most cases is many times greater than the cost of constructing and operating the works. Money paid to the doctor, the apothecary, and the undertaker is not, in one sense, a loss to a community, as it is merely a transference of money from one man's

TABLE VII.

CHARACTER OF WATER SUPPLY.

	Depreciation in Dollars per Million Gallons
1. Ground waters, except in cases where pollution is excessive, or where wells are driven in rock or soil abounding in fissures	$0.00
2. Filtered waters (assuming modern methods of construction and operation)	$0.00
3. Surface waters—	
a) Ordinary upland waters, with insignificant contamination	$ 0.00 to $ 15.00
b) Slightly contaminated waters, with good storage in lakes or large reservoirs	10.00 to 50.00
c) River waters, slightly contaminated, little or no storage	25.00 to 100.00
d) River waters, much contaminated, little or no storage	50.00 to 200.00

TABLE VIII.

EXAMPLES OF WATERS WITH DIFFERENT PHYSICAL CHARACTERISTICS.

City	Source of Supply	Turbidity	Color	Odor	Per Cent. of Objecting Consumers	epreciation per ue per Million Gals.
	GROUND WATERS.					
Camden, N. J.	Driven wells	0	1	0	0	0.00
Flatbush, L. I.	Driven wells	0	0	0	0	0.00
Lowell, Mass.	Driven wells	0	10	0	5	1.00
	SURFACE WATERS.					
Portland, Me.	Lake Sebago	1	15	2v	20	$4.00
Boston, Mass.	Sudbury and Nashua Rivers	3	25	2v	30	6.00
Cleveland, Ohio.	Lake Erie	18	5	1.5v	30	6.00
Worcester, Mass.	Storage Reservoirs	2	30	3v	40	8.00
New York City.	Croton River	4	20	3v	55	11.00
Brooklyn, N.Y.	Ponds and driven wells on Long Island	3	13	1.5g	36	7.20
Jersey City, N. J.	Rockaway River	4	32	2v 1g	38	7.60
Watertown, N. Y.	Black River	6	70	3v	55	11.00
Springfield, Mass.	Ludlow Reservoir	5	27	4g	104	20.80
Bangor, Me.	Penobscot River	6	65	3v 2m	59	11.80
Pittsburgh, Pa.	Allegheny River	64	30	3v 2m	87	17.40
Philadelphia, Pa.	Schuylkill River	150	10	3v 2m	102	20.40
St. Louis, Mo.	Mississippi River	200	30	3v 2m	127	25.40

Some of the above figures do not represent present conditions. For example, Watertown, N. Y., now has filtered water; St. Louis uses a chemically treated water; and soforth.

TABLE IX.

SEASONAL VARIATION IN THE DEPRECIATION VALUE OF A SURFACE WATER DUE TO SEASONAL CHANGES IN TURBIDITY, COLOR AND ODOR.

Month	Turbidity	Color	Odor	Per cent. objecting consumers.	Depreciation of value per million gals.
January	6	25	3v	44	$8.80
February	8	28	3v	47	9.40
March	7	27	3v	45	9.00
April	5	22	3v+	40	8.00
May	8	25	(3v 0.5 Org.o.3m)	40	9.80
June	7	30	(3v 0.3m)	48	9.60
July	4	22	(3v 0.5 Org.o.5m)	43	8.60
August	4	25	(3v 2. Org.o.5m)	62	12.40
September	3	30	(3v 1. Org.o.5m)	63	12.60
October	4	28	(3v 1. Org.o.5m)	49	9.80
November	3	26	(3v 0.3m)	40	8.00
December	4	25	(3v 0.3m)	42	8.40
Average	..	..	..	..	$9.53

TABLE X.

DEPRECIATION IN VALUE OF WATERS DUE TO HARDNESS.

State	City or Town	Source of Supply	Total Hardness (Parts per Million)	Depreciation per Million Gals.
Maine	Augusta	Kennebec River	20	$2.00
"	Waterville	Messalonskee River	15	1.50
Massachusetts	Boston	Sudbury and Nashua Rivers	12	1.20
"	Cambridge	Storage Reservoir	33	3.30
"	Pittsfield	Storage Reservoir	50	5.00
New York	New York	Croton River	40	4.00
"	Albany	Hudson River	64	6.40
"	Oswego	Oswego River	191	19.10
Pennsylvania	Philadelphia	Schuylkill River	179	17.90
Ohio	Toledo	Maumee River	200	20.00
"	Columbus	Scioto River	335	33.50
"	Warren	Mahoning River	578	33.50
England	London	Chelsea Company	215	21.52
"	London	East London Company	243	24.30

pocket to another's, but in the broader sense any loss of productive capacity or any unnecessary expenditure is a loss. Deaths from typhoid fever and from other diseases, however, represent a very material loss of the productive capacity of a community, and consequently a decrease in what may be termed the vital assets. In the case of the city of Albany, for instance, the increased worth of the water to the city, because of its efficient filtration, amounts to $475,000 per year, of which at least $350,000 may be considered as a real increase in the vital assets of the city.

If in the formula $D = \$2.75\ (T - N)$ we let $T - N = 1$, then $D = \$2.75$; that is, a decrease in the typhoid fever death-rate of 1 per 100,000 causes an increase in the vital assets of the city of $2.75 for each million gallons of the public water supply (assuming this to be 100 gallons per capita), or $0.10 per capita per year for each unit reduction of the typhoid fever death-rate per 100,000. In other words the decrease in the typhoid death-rate per 100,000 divided by 10 gives the increased vital assets of the community in dollars per capita per year. Thus in the case of Albany, above given, the reduction in the typhoid fever death-rate was 78 per 100,000. On the basis of 10 cents per capita per unit decrease, this would amount to $\$0.10 \times 78 \times 95{,}000 = \$741{,}000$ per year, assuming a per capita consumption of 100 gallons daily, or $450,000 for a per capita consumption of 165 gallons daily, which is the figure stated above.

Water-softening.—The following figures will illustrate the financial value of water-softening plants:

Winnipeg, Manitoba—	
Hardness of water before treatment	580
Hardness of water after chemical treatment and filtration	193
Reduction in hardness	387
Increased value of water due to water-softening process, per million gallons	$38.70
Oberlin, Ohio—	
Hardness of raw water	170
Hardness of raw water after chemical treatment and filtration	48
Reduction in hardness	122
Increased value of water due to water-softening per million gallons	$12.20

These figures refer only to water used for domestic purposes. If industrial uses also were considered the advantages of water-softening would be still more evident.

At the present time there are not many water-softening plants in existence in connection with municipal supplies, but the advantages to be gained are very great, and are becoming appreciated by the managers of railroads and industrial establishments. With a better understanding of the practical benefits to be derived from the use of soft water, it may be confidently expected that during the next 10 years the number of municipal water-softening plants will very greatly increase.

TABLE XI.

EFFECT OF FILTRATION ON ATTRACTIVENESS OF WATERS.

City	Source of Supply	Type of Filter	Sample	Turbidity	Color	Odor	Per Cent of Objecting Consumers.	Depreciation in Value. Per Mill. Gals.	Increased Value of Water
Lawrence, Mass.	Merrimack River	Slow sand	Raw	10	40	3v 1m	58	$11.60	
			Filtered	0	40	2v	28	5.60	$ 6.00
Albany, N. Y.	Hudson River	Slow sand	Raw	40	32	3v 1m	69	13.80	
			Filtered	2	24	2v	27	5.40	8.40
Yonkers, N. Y.	Sawmill Creek	Slow sand	Raw	6	30	1v 1m	49	9.80	
			Filtered	0	3	1v	4	0.80	9.00
Poughkeepsie, N. Y.	Hudson River	Slow sand	Raw	30	55	3v 1m	78	17.60	
			Filtered	0	30	1v	17	3.40	14.20
Binghamton, N. Y.	Susquehana River	Mechanical filter	Raw	30	20	3v	57	11.40	
			Filtered	0	5	1v	5	1.00	10.40
Watertown, N.Y.	Black River	Mechanical filter	Raw	6	70	3v	72	14.40	
			Filtered	0	8	1v	10	2.00	12.40
Little Falls, N.Y.	Passaic River	Mechanical filter	Raw	20	35	3v	56	11.20	
			Filtered	0	8	1v	10	2.00	9.20
Brooklyn, N. Y.	Baisley's Pond	Mechanical filter	Raw	15	31	2v	52	10.40	
			Filtered	2	3		7	1.40	9.00

Looking at the matter in another way, it may be said that the purification of a polluted water is a sort of life-insurance for the people, the value of which is equal to 10 cents per capita for each unit decrease in the typhoid fever death-rate per 100,000 which it brings about. Such a sum capitalized represents a large amount of money. In Albany, for example, where the typhoid fever death-rate has been reduced 78 per 100,000, the annual saving of life-value would be $7.80 per capita. Capitalized on the basis of an annual life-insurance premium of $17 per thousand, this would represent an insurance policy of about $460 per year for each inhabitant, or $2,300 for each head of a family.

Physical Quality.—The figures of Table XI show the effect of filtration on the attractiveness of waters—that is, upon the aggregate effect of their physical characteristics.

The above figures do not pretend adequately to represent the conditions in any of the cities included in the list, as the analysis is each case represents only one date. They are, however, typical of what the filters in the various places are doing, and they indicate that the increased value of water, because of its filtration, is as great as the cost of the works—in some cases it is even greater. Thus if the effect of filtration on the sanitary qualities of these waters is entirely ignored and only its effect on their physical qualities considered, the filtration of these supplies would still be a profitable undertaking from a financial standpoint. If the sanitary qualities were also considered, the advantages of filtration would be found to be many times greater. This phase of the subject has not received the consideration it deserves, and it is this topic which the writer desires especially to emphasize in the present paper.

Summary.—In the foregoing paper attention has been called to the following propositions:

1. Pure water as compared with impure water has a real financial value to a community. 2. This value may be measured by determining what impure water costs the community. 3. There are three principal characteristics which affect the value of water to the general consumer—its sanitary quality, its attractiveness, and its hardness. 4. A formula is suggested for computing the effect of the sanitary quality of water on its financial value to a community; it is based on the typhoid fever death-rate. 5. A formula is suggested for computing the effect of the general attractiveness of water on its value to consumers; it is based on the physical characteristics of turbidity, color, and odor. 6. A formula is suggested for computing the effect of the hardness of water on its value to the consumers; it is based on the use of soap in the household. 7. Considered from the financial aspect alone, and disregarding all humanitarian considerations, the filtration of a polluted water supply adds very greatly to the vital assets of a community; hence, as a mere business proposition, no city can afford to allow an impure water supply to be publicly distributed. 8. The advantages to a community of having a water supply, not only safe, but also attractive in appearance, taste, and odor, are material from a financial aspect; the increased value of many waters because of the improvement in their esthetic qualities alone justifies the cost of filtration. 9. Water-softening at present does not receive the attention it deserves at the hands of municipal authorities; the economic advantages to be gained by removing the hardness of water are so great that, in many cases, the saving to the ordinary water-consumers justifies the cost of softening-water. 10. The formulas here suggested and the detailed results derived from their use are not to be considered as of great accuracy, as the assumed data are not fully adequate; they are given merely to show the possibility of computing the value of pure water in terms of dollars and cents, and to illustrate the financial value of filtration and justify its cost.

A New Sea Wall at Annapolis.

The difficulty which has been experienced in the past in maintaining a sea wall along a portion of the water front of the grounds of the U. S. Naval Academy at Annapolis has apparently been overcome by a type of sea wall recently completed there. The scheme for the improvement of the Academy involved the acquisition of property on the shore and the reclamation of land on the water front between an old and more recent sea wall. The old sea wall was a stone structure built on the natural bottom and was constructed merely as a protection for the banks. The more recent sea wall was built in connection with a power station located on a pier extending some 400 ft. from the shore line and had caused considerable trouble before it was finally made stable. The construction of the sea wall that has recently been completed along the reclaimed land was described before the Engineers' Club of Philadelphia, by Mr. Harrison W. Latta, from which description the following notes have been taken.

Plans were prepared for a wall supported on piers spanned by concrete arches, the work to be divided into six sections. Back of the wall were reinforced-concrete arches spanning the same piers and relieving the wall from the thrust of the back filling, holding this back filling so that the toe of the slope came within the line of the wall. The Government had decided to do the work by day labor under the direction of its engineers, and had purchased considerable material with this idea in view. This decision was changed, however, and proposals for the construction of the sea wall were invited, the Government agreeing to furnish such materials as it had purchased, which would be available for the construction. The bids were received on the different sections of the wall. One section was of simple construction, being designed as a retaining wall, there being but 3 ft. of water in front of it. The total of the lowest bid was very largely in excess of the appropriation, but on another section the bids were close and that particular portion of the work was awarded at the time, in June, 1903.

It was then necessary to make a new and more economical design, keeping in view the use of the materials already purchased for this work. The result was a concrete wall built directly on the piles, without any cribbing or caisson work. As this wall extended only 5 ft. below water, the required depth of water, 20 ft., was secured by a riprap slope in front of the wall. On this design of wall the prices bid came within the appropriation and the contract for the construction was awarded in July. The contract was held up until October, however, by legal difficulties. As a special plant was required for the work, the season was at that time so far advanced that nothing could be done until the following spring, except pile-driving and some of the filling.

During that winter, however, the plant for

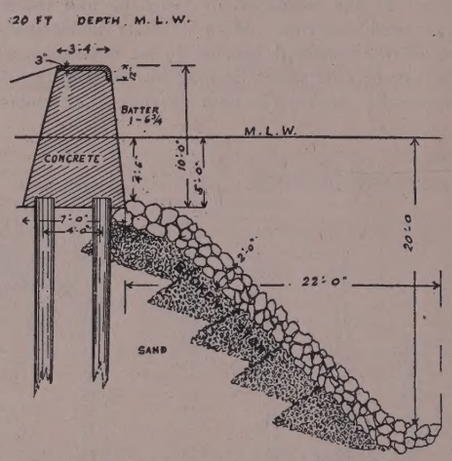
handling the work, including three scows, chutes for placing the rip rap, forms for the concrete, etc., was built. One scow was 23 x 80 ft. in plan and 8 ft. deep and carried the concrete mixing and handling plant. This plant consisted of a Hains mixer mounted at the middle of the scow, with a derrick at each end, one to handle materials and the other to handle concrete from the mixer to place in the wall. A second scow carried a circular saw mounted on a vertical shaft for cutting off piles under water, and a derrick used in placing and removing the concrete forms. A third scow was used for water and for hauling materials for the construction. The design of the wall as built is shown in the accompanying illustration. The fill back of the wall was first made by scowing in dredged sand, to an elevation of about 6 ft. below mean low water. When this fill had been made out to the line of the wall the piles were driven. Using these piles as a guide the crushed stone and large rip rap were placed, a dredge first excavating to the proper depth in front of the wall.

The scow on which the rip rap was delivered was moored broadside to the piles and held off at the proper distance by wooden frames. Between the scow and the piles was placed a wooden chute 40 ft. long, 5 ft. wide and 5 ft. deep, with an opening in it 2 ft. wide, running nearly its entire length. The stone was dropped through this opening, until soundings taken through the chute showed the rip rap had been brought up to the proper elevation—the position of the chute being known, the correct elevation for the rip rap could be determined. When the proper elevation had been reached the scow and chute were moved in 4 ft. and the operation was repeated until the crushed stone had been brought up to the line of the piles. The large riprap stone was then placed in the same manner. The piles were then cut off 4½ ft. below water with the circular saw mounted on a vertical shaft, after which the work was placed.

The concrete forms were built in 12-ft. sections, fastened together at the top with a cap piece and at the bottom by a wire to keep them from spreading, with a brace to hold them apart. By removing the cap-piece and cutting the wire, which was below the water, the two sides of the form came off and could be used again. The method of procedure was to remove six or eight of these 12-ft. sections from the completed wall and place them on a scow, where the two sides were set in an upright position, connected by the cap-piece at the top and braced and tied across the bottom. Each section was then raised by the derrick, set down in the water and bolted to the section of form which had not as yet been removed from the completed wall. The section thus placed was held to the proper elevation by long stakes driven in the sand. It was then spiked and held in line by braces spiked to it and to the brace piles driven back of the line of the wall. In this way the several sections of form were placed. The sand was then filled in back of and between the forms to bring the bottom to the required grade. In the front the riprap was brought up to the completed grade and filled against the form with small crushed stone to prevent concrete from escaping under the lower edge. The work was then ready for the concrete to be brought up to the water line.

The concrete was mixed and placed as follows: Sand was brought in on small schooners and loaded into bins on the mixing scow after working hours. Stone was delivered on barges holding about 300 cu. yd. These barges were placed alongside the mixer scow so that the derrick could reach the stone and hoist it directly from the scow to the mixer. This derrick also hoisted the sand and cement. The mixed concrete fell from the Hains mixer into a bucket placed on a car in the hold of the scow. This car was pushed to a point where the other derrick on the scow could reach the bucket. An empty bucket was placed on the car and a full one taken away. The derrick then lifted the bucket of concrete and placed it in the forms. When the bucket reached the bottom, the opening in it was released and the concrete deposited in place. This process was continued until a section of wall about 60 ft. long had been brought to the surface of the water. The following day planks were placed on the part of the form above the water and the wall brought up to within a foot of its finished height.

When the concrete work was first started it was intended to make the concrete under water continuous; that is, to leave a slope at the end of the wall at night and begin by placing the next day's concrete on this slope. It was found, however, that there was a deposit of magnesia, caused by a reaction between the sea water and cement, which settled on this slope and on the bottom, ahead of the concrete work. As this deposit could not be removed without great difficulty and expense, it was found necessary to place a bulkhead in the forms and end the day's work at that bulkhead. In this way the deposit was forced out from between the forms before it



Cross-Section of Latest Sea Wall.

had time to settle, and it was found scattered over the bottom outside the line of the wall where it could do no harm. These bulkheads also furnish expansion joints in the wall—a sheet of tar paper being placed against the completed work before fresh concrete of the succeeding section was placed against it.

When dried out the deposit of magnesia was of the consistency of an impalpable powder and when wet was like a liquid grout of neat cement. It did not harden in the sense of setting, but it became more compact as it settled or was compressed. It would cover the bottom between the forms and would sometimes accummulate to the depth of a foot around the piles, and these being 5 ft. under water, there was considerable difficulty in removing it. By bulkheading, the water holding the magnesia in suspension was forced out from between the forms, and the deposits occurred outside the line of the forms where they could do no harm. The removal of this magnesia did not in any way affect the properties of the cement. The concrete set up as well as any with which Mr. Latta has had experience. The forms were usually removed in 48 hours, but could have been removed in 24. In beginning the construction, a section of wall 100 ft. in length was built before this deposit of magnesia interfered with the work. It was then found to a depth of from 6 to 12 in. and extended to a distance of about 70 to 80 ft. from the end of the complete wall. It was found by sounding with a rod and could be easily recognized. If a section of the wall was left uncompleted, with its top surface below the level of the water, the deposit would occur on this surface, and would have to be removed before more concrete could be placed.

After the wall had been brought up to four feet above mean low water, the fill back of the wall was completed by dredging material from the front and casting it over back of the wall.

The concrete of the upper part of the wall, 1 ft. in depth, on which a granolithic finish was placed, was laid after the backfill was made, forms being clamped to the wall already built.

A section comprising a breakwater adjoined the wall of the power-house pier, which had been built by another contractor and had failed. So far as securing a suitable and stable foundation was concerned, this piece of the work was the most difficult of the entire contract. The breakwater was only 110 ft. long and 30 ft. wide, but it was known that at that location there was a deep deposit of almost liquid mud. To secure a foundation it was necessary to replace this mud with sand. Sand was dredged and brought in to the site of the breakwater on scows and dumped until its weight pushed the mud out into a shoal of mud on either side. These shoals were removed by dredging and the sand settled. More sand was then scowed in and the shoals, which again formed, were dug away. This operation was repeated until almost 20,000 cu. yd. of sand had been dumped on the site of the breakwater and a like amount of mud removed. It was then found that the removal of the mud did not result in further settlement of the sand fill.

The work was then considered ready for the driving of the piles. On the outer end of the breakwater, single sticks ranging in length from 70 to 85 ft. in length were driven. Toward the inner end the bottom was worse and lengths of 100 to 110 ft. were required. Single sticks of this length could not be secured and it was found necessary to resort to splicing. After a trial of several methods, the simplest was found to be the best. The first or bottom pile, 60 to 70 ft. in length, was driven until the top was within about 3 ft. of the water surface. This top was carefully adzed down to a plane surface and trimmed to a diameter of 10 in. On this was placed a piece of 10-in. wrought-iron pipe 10 in. long. The top pile, the point of which had been carefully trimmed to fit on the pipe, was now raised in the leads and set on the lower pile. The driving was then continued until the required penetration was reached.

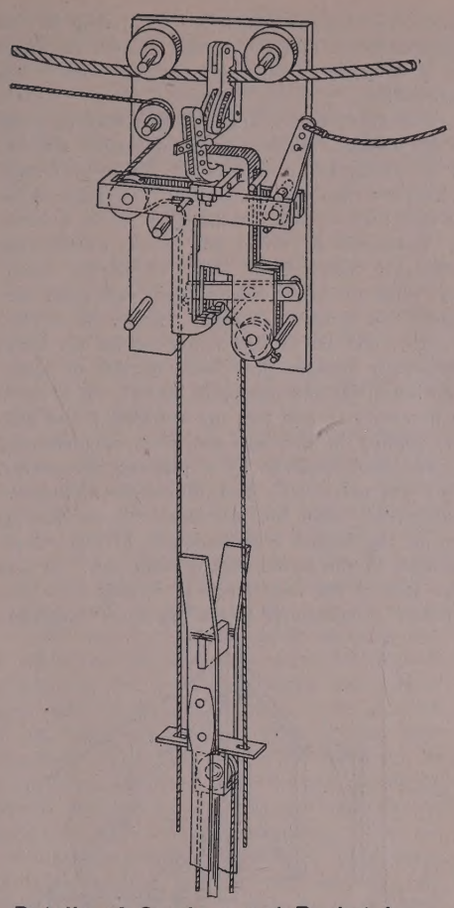
On the foundation, constructed in this way, the wall was built, which has not settled in the least, although at the time of the construction the old wall with which it connected was still settling.

THE SINGLE-PHASE SYSTEM of traction is now being installed on the South London line of the London, Brighton & South Coast Ry. between the Victoria and London Bridge stations, and it is expected that steam will be superseded by electricity on this section in about a year. Two features of the undertaking are unusual; the first is the decision to purchase current from a public service company rather than to generate it, while the second is the award of the general contract for the electrification to a German firm. This latter feature, in the face of the present British feeling regarding German competition, would be a step not calculated to make the railway popular had the contract not required everything but the car equipments to be of home manufacture. As the contract calls for only eight trains, each of two motor cars and a trailer, the foreign-executed portion of the undertaking is of slight extent. In this connection, it may be added that the Midland Ry. has adopted the single-phase system for its Lancaster, Morecambe & Heysham lines, although little further official information concerning the matter is yet available.

A Novel Cableway System of Coal Storage.

The coal storage plant for the American Print Works, Fall River, Mass., has a capacity of about 20,000 tons and is arranged to unload coal from vessels and deposit it on shore by one operation and to distribute it in open storage and deliver it to the coal bins at the boiler house in two successive operations, all performed with different installations of a special type of cableway and hoisting apparatus. The plant is arranged as shown in the accompanying general plan and elevation, and consists essentially of the unloading apparatus and the storing and delivering apparatus. Unloading is accomplished by two fixed towers with special hoists which deliver the coal at two points under a cableway which commands the storage yard and distributes the coal in it; afterwards transferring it as required to the boiler house.

The unloading towers are duplicate wooden structures 70 ft. apart on centers which are seated on the edge of the pier and are provided with booms overhanging it 26 ft. From the extremity of the boom a 1¼-in.. steel cable leads to the top of the tower 76 ft. above the surface of the ground. On this cable a special trolley hoist is operated and carries the coal tub from the hatch of the vessel to the top of the tower where it is dumped on an inclined apron that delivers the coal under the main cableway. The boom is in reality a cantilever truss supported at the rear on rollers that enable it to move back and forth 26 ft. transverse to the pier line. These rollers are seated on a carriage which moves across the face of the tower about 25 ft. parallel with the pier line, thus providing adjustment to carry the end of the boom over the hatch in any position in which the vessel may be moored to allow both towers to be simultaneously operated. The upper end of the cable passes over a fixed sheave in the top of the tower and to provide adjustment for the varying distance between this point and the end of the traveling boom, the free upper end of the cable is attached to a compensating device with a heavy weight proportioned to develop necessary tension in the cable. The operating machinery not here shown is located in the tower and provides for the hoisting and lowering of the bucket and the movement of the trolley back and forth from end to end of the cable. Each tower is designed to handle 40 tons of coal per hour, and the elevation of the dump is such that about 1,000 tons can be stored in the conical pile that may be formed in front of the tower.

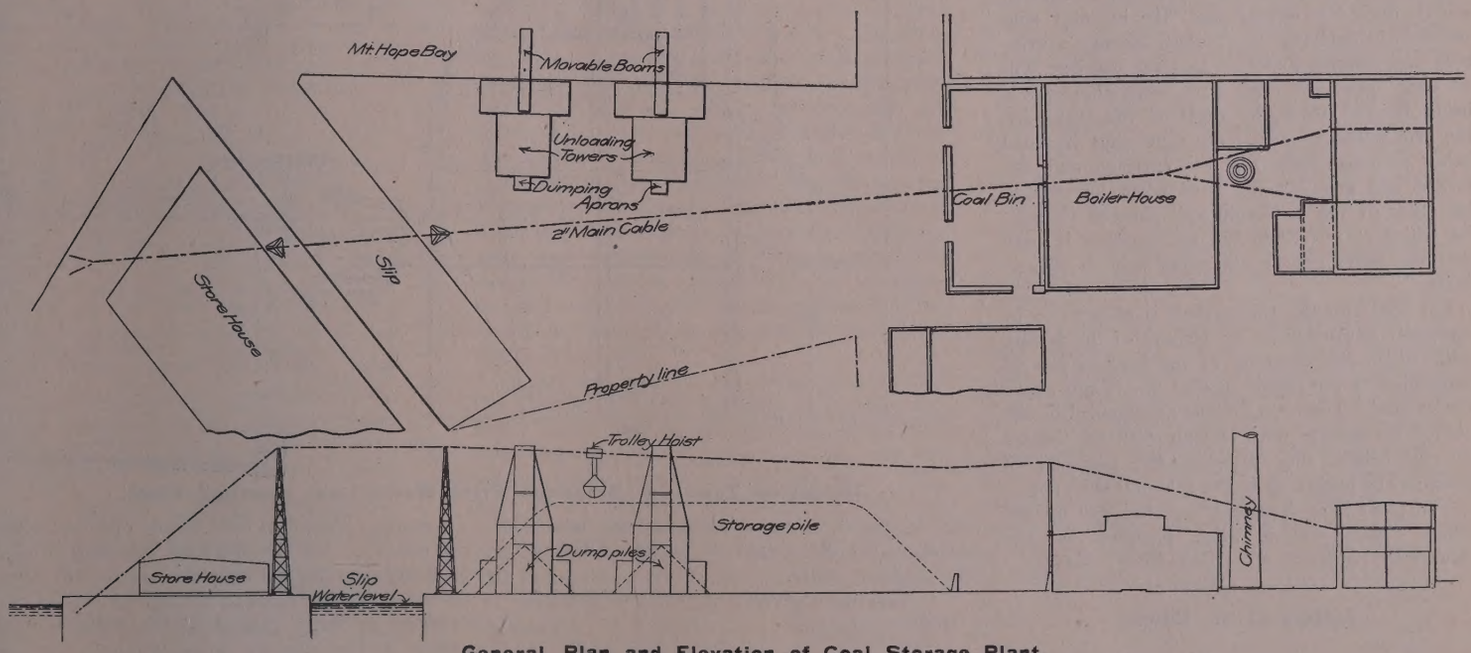


Details of Carriage and Bucket Jaws.

The main cable for the distribution and delivery of the coal is a patent lock steel wire rope 2 in. in diameter, which passes over the dump piles and extends from end to end of the storage ground and beyond it at both ends to anchorages about 640 ft. apart. The main span of the cable is supported on two wooden towers about 65 and 75 ft. in height and 309 ft. apart. It is under tension sufficient to reduce the maximum deflection to about 16 ft., so that the minimum clearance above the surface of the ground is about 55 ft. One of the towers is adjacent to a slip in which boats are received. In order that the cable may clear their spars, it is carried across the slip to the top of a second 75-ft. tower and thence leads at an angle of about 45 deg., to an anchorage below the surface of the ground. The opposite end of the cable leads from its tower to an anchorage passing through the second story of a stone building which is utilized to provide reaction for the stress in the cable. The design is complicated by the existence of a tall brick chimney on the center line of the cable, which latter is divided into divergent branches to clear.

The pyramidal towers are triangular in cross section, made with three 12x12-in. posts 10 ft. apart on centers at the base and united by diagonal braces from 4 x 6 to 6 x 8 in., and by 1¼-in. horizontal tie rods. The anchorages are made with U-bolts engaging sockets at the ends of the cable and provided with long screw adjustments. The loops engage pairs of 3-in. rods embedded in the concrete foundation blocks where they have nut bearings on reaction pieces.

An essential feature of this plant is the special device provided for automatically locking the carriage to the cableway while the load is being hoisted and lowered and releasing the carriage from the cable and locking the bucket to it when the latter is being traversed in either direction. This device is somewhat complicated and is operated by jaws which project above the bucket and engage with guides in the bottom of the carriage, thus providing for the contact of the different parts of the locking and releasing mechanism when the bucket is hauled up to the carriage and when tension is applied to either the hoisting rope or the dumping rope by means of which alone all operations are controlled. A diagrammatic view of the carriage and the bucket jaws is shown in the accompanying detail drawing where one of the side plates of the carriage is removed to expose the mechanism. This shows clearly the grip engaging the main cable which is locked when the bucket jaws engage its lever and unlocked when they release it. The hoisting and dumping lines are shown below the cable and in the lower part of the carriage the hooks are visible which support the bucket in transit.



General Plan and Elevation of Coal Storage Plant.

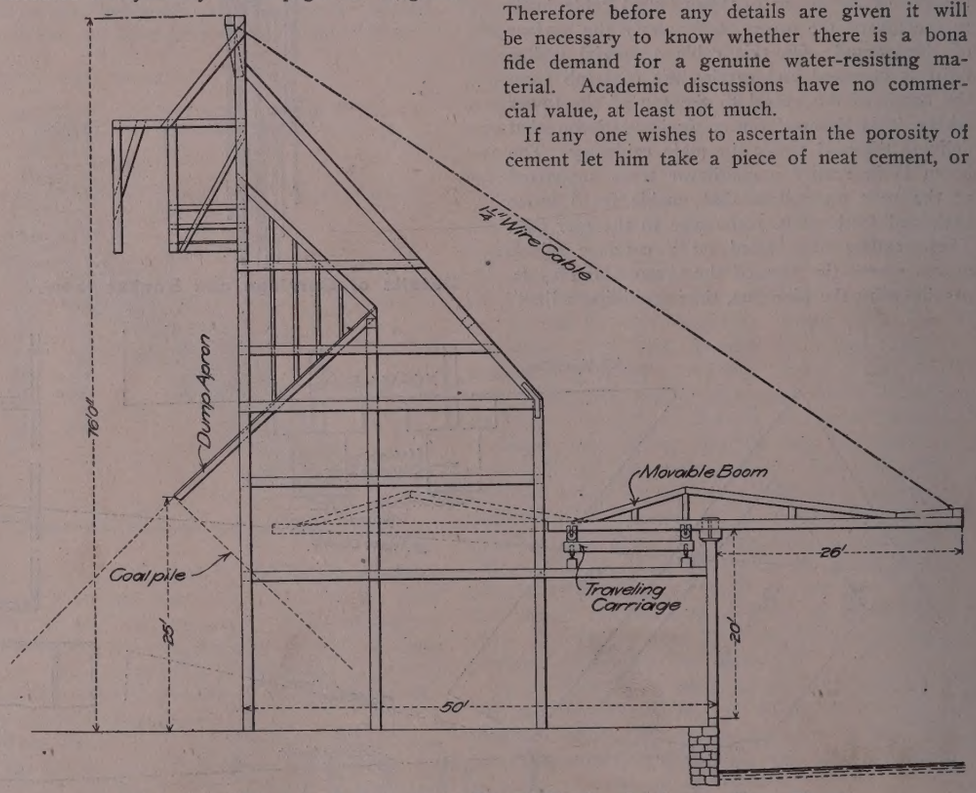
With this device it is estimated that the plant can be operated by one man on each tower hoist and one man on the main cable, and that it can handle 800 tons of coal in 10 hr. as compared with 400 tons handled by the former plant which employed two engine men, seven laborers, seven dump carts, seven horses and seven drivers and loaders. The contract was awarded following a satisfactory operation of a full-sized

working plant with a cableway 416 ft. long and a three-ton bucket suspended from the patent carriage. This handled a large amount of coal satisfactorily and demonstrated the efficiency of the apparatus. The special advantages claimed by the designers relate to the mechanism and operation of the bucket and carriage for which they claim especially, greatly reduced friction, rapid travel (a speed of 1,000 ft. per minute for the bucket), simplicity of construction, positive action and small power consumed, the ability to hoist the load to the cable, the method of locking the carriage to the cable and releasing the hoist line or vice versa by a single operation and the fact that only one operating line is in use at the same time, thus eliminating the tension developed on the second line by other systems, avoiding the difficulty of one line pulling against the other and making a much smaller engine available for the duty.

The promoters of this system consider that one of the principal merits is the applicability of the carriage and bucket to any existing line of cable or aerial rail support, particularly in the case of apparatus for coaling ships at sea where the fact that only one operated line is in use at once allows the carriage to adjust itself to the motion of the sea. It is stated that sixty 100-lb. bags of coal can be taken at each trip from the hull or deck of the transport, hoisted to the cable, locked to the carriage, transported to the battleship, unlocked and lowered to its deck with rapidity and safety even when the sea is comparatively rough. The system can be operated by a single-drum engine on each vessel or by a double drum engine on either vessel. The promoters claim that the device fully meets the requirements attributed to Admiral Sampson, who is quoted as saying that "the inventor who succeeds in applying to a trolley carriage a gripping and locking device so that the carriage will be firmly gripped to the wire when the load is being hoisted from the deck of the transport, the grip releasing and at the same time the load being securely locked to the carriage and unlocked and gripping the wire when lowered to the deck of the battleship will succeed in coaling ships at sea when the sea weather is such that the wires can be run from ship to ship in safety."

For coal storage, this system is claimed to be especially advantageous on account of the facility with which the dumping of the buckets can be controlled by the engine man at any height above the ground. Time can also be economized by the ability to operate the carriage with the bucket at any height, thus avoiding the necessity of hoisting the bucket up to the cable on each trip.

The plant here described was designed by Mr. Clark Chase, and is being installed by The American Cableway Co., Fall River, Mass.



Unloading Tower of American Print Works Coal Handling Plant.

Letters to the Editor.

JAMES DREDGE.

SIR:—Probably few Americans appreciate the interest taken in engineering affairs in this country by the late James Dredge, for many years one of the editors of "Engineering" of London. Years ago, as a youth in the office of that journal, he came under the influence of the strong and gracious personality of Alexander Holley, one of the leading American engineers of his time. He also absorbed the good ideas of Zerah Colburn, the famous American mathematician, who founded that journal. He visited this country several times and made careful personal studies of our methods and the conditions that made those methods successful. As a result of these influences and this knowledge he was, in some respects, one of the best representatives we had in Great Britain. Although he was thoroughly British in every way, he was quick to see those directions in which we could help British manufacturers, and the tactful manner in which he gave printed expression to his views was noteworthy.

In another respect, also, mention may be made of his career. He was an indefatigable worker; in his ability to produce results he seemed more a machine than a man. A few years ago, while so sick that his life was hanging in the balance, he continued to direct the work which most interested him. Even after his partial recovery, while his health was so poor that most men would not think of business affairs, he worked steadily, and but a few hours before his death was busily engaged on a book relating to American industries and industrial leaders. It is hardly necessary to add that his knowledge and ability, applied in this manner, were supplemented in an equal measure by a pleasing personality. This was particularly seen during the Columbian Exposition, when his tact made his services as one of the British commissioners of marked assistance to the authorities of that fair. It was also seen in the wide circle of friends who contributed anonymously to the pages of "Engineering," giving its editorial utterances on important questions all the weight of expert testimony of the highest order.

Very truly yours, X.

Boston, Sept. 6.

WATERPROOFING CEMENT.

SIR:—Referring to some recent correspondence in your columns on the subject of waterproofing cement I beg to offer a few remarks.

The means of arriving at this end are not plentiful; while it may be comparatively easy to waterproof a dam it is quite a different matter with a bridge or a building where the dam methods are not always applicable. At present engineers seem limited in such cases to a drain and a pump, which combination is certainly efficient, or to soluble ingredients having a longer or shorter life according to the surrounding conditions.

One writer goes so far as to say that waterproofing is a modern institution, forgetting that 3,000 to 4,000 years B. C. two arks are mentioned by Moses, both of which had considerable attention paid to this feature. So far from being new it has always been a cause of trouble.

To-day, if we except the pump, we are following exactly the same lines as these primitive boat-builders, namely, keeping out water by means of soluble materials which is all very well as long as said materials last. It may be laid down as a general rule in these cases that whatever washes on or into cement surfaces will wash off or out; and that is the crux. Any amount of chemical combinations of soluble materials are boldly claimed by interested parties as permanent, but a little reflection exposes the fallacy. Until recently I have always advocated the pump remedy, for though troublesome, it is effective, but recent consideration of the question has led me to conclude that soluble materials, such as asphalts, may be utilized for waterproofing as part of a system and to lose all or most part of their solubility; at any rate permanent waterproofing is perfectly feasible.

But this method won't suit the cheap builder; it will cost from 15 to 25 cents per foot, and, of course, waterproofing at 3 cents a foot will usually win if it can be made to keep up some kind of appearance until the structure is sold. Therefore before any details are given it will be necessary to know whether there is a bona fide demand for a genuine water-resisting material. Academic discussions have no commercial value, at least not much.

If any one wishes to ascertain the porosity of cement let him take a piece of neat cement, or 1:1 mortar, pressed as hard as any ordinary press can make it. Let him submerge one-third of this in water and before long the water will have saturated the test piece to the top. So far as the sediment in water closing up the pores is concerned it may, and no doubt it does so in the course of time to some extent, exactly as happened in the old sandstone drip filters of former years. The flow diminished after long use, but as for closing the pores of the stone so as to be anything like impermeable no one ever lived long enough to see it. Again in limestone caverns (more impermeable than concrete) the formation of stalactites goes on continuously, apparently unaffected by the sediment which has been supposedly cutting off their water for unknown ages; the water gets through all the same, fissures or no fissures.

I made a number of tests some time ago as to the absorbent properties of various stones. Granite was the lowest with 2 per cent. cement, cement mortar and artificial stone were the highest; all about the same, 11½ per cent.

Yours truly, H. J. LIVINGSTON.

Baltimore, Sept. 3.